School Science

VOL. II] MAY, 1902. [No. 3

PROFESSOR REMSEN ON THE TEACHING OF SCIENCE.

BY LYMAN C. NEWELL, PH. D.

The Twentieth Century Club of Boston, Mass., provides a course of lectures each winter for the benefit of the teachers of that city and vicinity. President Ira Remsen of Johns Hopkins University recently delivered a lecture in this course on "The Place and Function of Science in Popular Education." The lecture was a lucid exposition of this teacher's views on science teaching in general and on the teaching of chemistry in particular.

In answer to his first question, "What distinguishes science studies from other studies?" he said:

"Science studies are, or ought to be, distinguished from other kinds of studies by the fact that they bring the pupil into direct contact with the things or phenomena he is studying. He is called upon to use his own eyes and his own mind. There is a direct connection between statements he may make and facts that he knows to be true as a result of his own experience. In their first stages, in their simplest forms, this should be the most prominent feature of science studies. Any course of study that depends largely upon what a lecturer may say or upon what a pupil may read in a book can never be a science course, no matter what the subject, no matter how good the lecturer, or how good the book. The essential feature of direct contact is lacking. So also the emphasizing of the theories of a science, no matter how important those theories may be or how well they may be established, should not play an important part in a science course in its early study. As far as this fact is lost sight of, the course is not scientific. It is not scientific, for example, to present and discuss the atomic theory in an elementary

course in chemistry, or the electro-magnetic theory of light in an elementary course in physics, or the nebular hypothesis in any course. The pupil must first learn how knowledge is acquired by direct contact. This lesson must be impressed upon his mind before he can profitably take up the profound thoughts to which scientific investigators have gradually been led—thoughts which are based upon an immense accumulation of facts learned by direct contact."

He then showed how language, mathematics, and history do not meet these tests, and are therefore not science studies. Much to the amusement of his hearers, he then said that many science courses—so-called—would not meet this simple requirement, viz., the element of direct contact. "They are mere masquerades," he said.

In answer to his second question, "What ought science studies to accomplish?" he said in substance:

"It is often stated that the object of science studies is to develop the power of observation. This is true, but it is far from being the whole truth. There are other ways of developing this power, perhaps better than by pursuing elementary courses in science. Life on a farm or life out of doors tends in this direction. The savage probably has the keenest powers of observation possessed by any member of the human race. He gets his knowledge and his power, not by studying books, but by direct contact with the things around him; that is, by the scientific method. Science courses should teach more than the power to observe. They should teach how to draw conclusions. They should lead to a scientific state of mind. By this is meant a state of mind that enables the possessor of it to take the most direct course in dealing with any problem that may be submitted to him; that enables him to see through the mere talker, through the shams, and go back to the facts and draw his conclusions from them; that enables him to discriminate between what is known and what is imagined. That state of mind called *unscientific* might be described as the average state of mind, that state of mind which accepts popular superstition or which has undue willingness to talk much on topics little understood."

As to how far science courses accomplish what they are designed to accomplish, he said: "Not far, but it is better to get a glimpse than no look at all. Probably the average course of science does comparatively little toward putting the pupil in a scientific state of mind. Still, if this kind of study is right in principle, and in regard to this there can probably be no doubt, the pupil ought to have at least a taste of it. Some pupils will, of course, be much more benefited than others. Some will be inspired by this kind of work. No one can be harmed by it. If the courses were what they ought to be, then all the pupils ought to be, and probably would be, benefited by them. The ideal course is one in which the pupil makes daily observations, spends a certain amount of time in reflecting upon what he has observed, and then from time to time is led to see the connection between his own observations and some of the important generalizations that have been reached, which, taken together, form the ground-work of the sciences. The usual results of a year's work in chemistry are meagre." He then illustrated this point by some answers received by him from entering students.

He gave many practical suggestions in answer to the question, "How can science courses be improved?" saying substantially:

"The greatest need is that the courses be made more scientific. Everything that is labeled scientific is not necessarily scientific. Indeed, some of the most unscientific courses I have ever known have been called scientific. Studying chemistry by listening to a lecturer and seeing him do things, or by reading a book, may be scientific as far as it goes, but is more likely to be more unscientific. Even experimenting in a laboratory is not necessarily scientific. Imperfect observations of complex phenomena, and the writing of statements supposed to be based upon what has been seen, but really drawn largely from the printed laboratory guide—these processes are not scientific, and they cannot lead to good results. They are more likely to do harm than good, as they involve waste of time and give false impressions in regard to scientific methods. Nor can the best work be accomplished by turning the pupil loose in the laboratory and letting him experiment without supervision. The questioning teacher is necessary in order that

good results may be reached. The teacher has here a splendid opportunity. Questions in regard to work done in the laboratory are of much more value than questions on matters studied from books or heard in a lecture room. The proper guidance in the laboratory demands the constant attention of the teacher; and, further, the teacher must have a full appreciation of what is meant by the scientific method. Such teachers are rare, whether in school, or college, or university. Undoubtedly the teachers of languages and mathematics are, in general, better fitted for their work than the teachers of science. It seems to me that what is most needed in our science courses is greater simplicity. The simpler phenomena should be studied so that the pupil's mind may be able to cope with the things he sees. The thoughts presented to him should be simple. He should be made to understand what he is doing and what he is talking about. If he shows a tendency to use words or symbols without being able to explain what he means, he should be corrected, just as if the subject were language or mathematics.

In regard to the laboratory work, which must be the basis of science courses, more care should be given by the teacher to secure *good* work. The pupil should be compelled to avoid slovenliness. A bad piece of apparatus is as bad as a bad piece of grammar or a bad mathematical demonstration. And in telling the story of his work, orally or in writing, the pupil should be held responsible for faults in language as well as in observation. Accuracy is an important feature of scientific work, and this the pupil should be led to feel."

The lecture was enlivened by many witty remarks. For example, "atoms are not fit food for infant minds," "some people don't suppose you have to have any facts to get up a theory," "a book with no reference to the atomic theory would never sell," "let the pupil observe and then observe him," "the most accurate language is the most scientific," "once it was all atoms, now it is all ions," "pupils are too ready to say 'haven't had that yet.'"

These thoughts have been reproduced from very brief notes in the belief that the readers of School Science may find them helpful in daily work.

CHEMISTRY IN EDUCATION.

BY C. L. SPEYERS.

Professor of Chemistry in Rutgers College.

(*Concluded from page 75.*)

The work in qualitative analysis will occupy about a year. In the case that general chemistry precedes qualitative analysis, the time given to the latter can be lessened, and the first part of the second year given to general chemistry, so that the latter may have somewhat over a year. For general chemistry in the laboratory, I look upon as very important. It is the study of the elements without particular attention to their detection and to their quantitative separation.

The experimenting involves the construction of apparatus, and this is a part of experimental chemistry that is of exceeding importance. The manipulations of analytical chemistry are in general very simple, not calling for any particular skill beyond that needed to avoid mussiness. As Professor Chandler of Columbia University used to say to his classes, "Anyone can be taught analytical chemistry. I could take the janitor and make an analyst out of him." With experimental chemistry the matter is different; experimental chemistry teaches constructive ability. It is by no means a simple matter for a beginner in experimental chemistry to put together a piece of apparatus for preparing moderately pure hydrogen, and if hydrogen is to be prepared as pure as possible, the necessary apparatus would tax the skill of the best chemists, far beyond that of the ordinary analytical chemist. Glass working itself is an art, and yet the research chemist must be acquainted with it as a very essential part of the construction of apparatus. I suppose it would be possible to run to the glass blower for every piece of apparatus designed, but it would certainly be highly inconvenient, exhausting, and involve a large part of the active hours, and the cost would be very great, particularly since the apparatus finally adopted is seldom like that first planned. Even for the student who does not propose to follow chemistry as a profession, a

practical knowledge of glass blowing implies valuable manual training; it implies a delicacy of touch that is useful in more ways than one. Moreover, the ability to construct a piece of apparatus in just the right way without makeshifts of cork and rubber often makes the difference between the success and failure of an experiment. So I would insist right at the beginning on clean, accurate fitting of just the right apparatus; very seldom should any makeshift be allowed. The rest of the experiment will then in many cases take care of itself. In the case of beginners, I would say, better an unsuccessful experiment with good apparatus than a successful one with badly constructed apparatus. A careful examination will soon show why an experiment fails, and a repetition brings success when the apparatus is properly constructed, whereas a badly constructed piece of apparatus may bring success once in a while, but is sure to bring failure often.

Dirty work is supposed to have been cured in the preceding analytical course, but if the general chemistry precede the analytical, attention must be given to cleanliness. To some extent slovenliness cures itself in an analytical course, for a slovenly student will find that his mistakes are far more numerous than those of his companions who are neat. Still, an analyst can have his beakers, flasks and test tubes clean inside, but dirty outside, and his desk sloppy. This must be prevented as much as possible; it shows a lack of appreciation of the fitness of things, a lack of æstheticism, and æstheticism is by no means unimportant in scientific work. We find few successful men who are slovenly, and we all know the difference between a well written, neat letter and a carelessly written and blotted one. These things being all right, the next test is the getting of the desired substance, say sulfate of iron, ferrous sulfate. Then the quantitative yield. Does the student get all that he should, all that corresponds to the iron used? If he does not, within certain limits which will vary for each substance obtained, the experiment is to this extent bad, or perhaps a failure, and should be repeated. The preparation must also be pure, and here a previous knowledge of qualitative analysis will be very handy.

Parallel with this work should run a course of lectures on

general chemistry in a more detailed way than in the course of the first year, provided the first year was given to qualitative analysis. When general chemistry is the work of the first year in the laboratory, then the lectures at the beginning may be more detailed.

At the end of experimental chemistry, the student will be ready to take up quantitative analysis. I am not in favor of spending much time on this subject. Accuracy is taught more emphatically than in the preceding branches of chemistry, but it hardly broadens the knowledge of the student. There is too much routine work to justify any prolonged study for anyone not intending to become an analytical chemist, and even for him it is very questionable whether a larger knowledge of inorganic and organic chemistry would not be better than more detailed acquaintance with quantitative analysis. The methods of the latter are so apt to change. As soon as the student has gone through with the principal operations, which can be learned by making a dozen analyses or so, and requiring five or six months, I would pass on to organic chemistry. This is not the view that used to prevail, and perhaps would still call out some protest. Quantitative analysis used to be considered the ultimate object of the chemist, but with the recent advances in carbon chemistry and in physical chemistry that notion is passing away. In connection with quantitative analysis should go the theory of the balance and the calibration of a set of weights. A short lecture course on quantitative analysis should accompany the laboratory work. And this finishes the analytical work of the course.

Lectures in organic chemistry should begin right after the first series of lectures in inorganic chemistry has ceased, for to have a good theoretical knowledge of organic chemistry before beginning the laboratory work is very advantageous. Much attention should be paid to carbon chemistry or organic chemistry; it is of great importance and well organized; outside of physical chemistry, the best organized branch, but unfortunately only so in theory. In practice there is much to be desired. Comparatively few carbon compounds react in a sharp, well defined way, in the way that most of the inorganic substances react. Much experience and

judgment is needed in working with the compounds of carbon to carry many experiments to a successful end, so we have no satisfactory theories to account for such peculiar behavior. So that a very different faculty is developed by the experimental study of carbon compounds. Quantitative relations and purity of preparation are to be the leading criteria of an experiment in carbon compounds. The manipulations are in general very simple.

The majority of the common reactions of liquid and gaseous inorganic substances take place so rapidly that it is not possible to directly detect any time law nor any other law concerning the active substances during the time that they are reacting. But with carbon compounds this is not so; the reactions proceed in general slowly; rapid reactions with carbon compounds are apt to be of the nature of explosions. Wherefore that branch of chemistry which has for its field the investigation of what happens during a chemical change did not develop rapidly until after a large development of carbon chemistry. The most important theories of physical chemistry are based on the properties of carbon compounds, and so carbon chemistry forms a very fitting introduction to physical chemistry.

Wherever physics may be brought into the course, it is essential that it precede physical chemistry. And the mathematics will, of course, precede the physics. The old method of teaching mathematics for the chemist is undergoing a change. More than one book has been written on calculus, differential and integral, in which the geometrical illustrations have been replaced by physical and chemical illustrations.

Physical chemistry is the science of investigating chemical changes by physical methods. It seems, therefore, almost self-evident that before physical chemistry can be studied, the chemical phenomena to which it applies must first be studied. And this seems to me to be the proper view to take; yet, since physical chemistry has organized chemical activity in a remarkable degree, it is now possible to present some general notions of physical chemistry right at the beginning of the study of chemistry, in the first year. But I do not think it advisable to do so; for the above reason and because there is some uncertainty as to the correctness

of some very important notions in physical chemistry. An advanced student has sufficient judgment in regard to these uncertain points, but for a beginner in a science, I prefer sure ground; as little as possible of theory, as much as possible of fact. This uncertainty applies particularly to ions. A great deal has been learned with the notion of ions to guide the chemist, but most of the necessary experiments have been made in water solutions, and perhaps the ionic theory will have to be rejected when the countless other solvents are carefully examined. Indeed, according to the preliminary experiments of Kahlenberg in Wisconsin, the ionic theory is not applicable to all liquids. So I should prefer at the stage of development of physical chemistry, to bring it in at the end of the undergraduate course, when the mind of the student has much matured. In a few years more, perhaps, these questions will all be settled and then an outline of physical chemistry can profitably precede experimental chemistry in the first year. As physical chemistry is so well organized, it can be taught in two ways, the inductive and the deductive. The student being now in his senior year, I should prefer the deductive method; that is, I should prefer to express a particular class of facts in general terms, and then apply to special cases. This way will not do so well for immature minds.

Class room work should abundantly accompany laboratory work. Too much drill in the class room can hardly be given, provided the drill is of the right sort. I do not know whether it is the experience of others, but I have found that students seem to feel that anything involving memory is in a way despicable, and yet without a good memory well stored with facts, a man is heavily handicapped in scientific work. Our most eminent chemists are walking dictionaries of chemistry as well as powerful thinkers.

This finishes the sketch of what it seems to me a chemical course should be for the purposes of education. The majority of college graduates will stop at this point, so that the course for them will be only to show how chemists proceed to study nature, but those who intend to continue are supposed to be ready to pass on to the study of chemical investigation, to help advance towards that all important question as to the destiny of the universe and

the nature of life. In putting such a question, we of course imply the possibility of finding an answer. Some of us may be of the opinion that such a question to nature is idle, altogether idle, that the answer to it can never be compelled; it is only to be obtained by revelation. To those the study of chemistry will not be so far reaching; to them it will only mean a search for knowledge to place themselves in harmony with nature or to gain wealth. Both very meritorious purposes, and I am in sympathy with them, but I would also claim for the study of science the other far more powerful incentive. I would claim that we have already made visible progress towards the answer. The two laws of conservation of energy and of conservation of matter are two discoveries whose importance we are apt to underestimate. On these two facts depend indirectly the recognition of an all pervading substance which we call the ether, a substance which connects us with bodies inconceivably remote. We know that the activity with which we are endowed is indestructible, that the matter of which we are composed is likewise indestructible, and that we are in touch with the remotest parts of the universe. Is it, then, unreasonable to claim that we shall in time find out what development this universe is to undergo, what life is? I think not, and the way in which we shall find out these things, I would claim, will be a chemical way. Put away chemistry from the list of sciences, and we shall hardly find in those remaining means of justifying the laws of conservation of energy and of matter, and a recognition of the ether. We might think that biology, dealing with life, would serve better than chemistry, but before life can be defined, the material which permits life to exist must be understood, and this material the chemist deals with in its various forms. On the other hand, when it would seem that astronomy should tell us about the origin and destiny of the universe, we should not forget that the foundation of astronomy, gravitation, is still wanting an explanation, and that the chemist is the one to give it. Whatever view we may take of the universe, we finally come back to the substances that the chemist deals with, and so we should look to him for an answer to the questions put at the beginning.

This is not a materialistic doctrine. It does not say that we have in matter all that is needed to account for life and to

foretell the destiny of the universe. Not at all. It does claim, however, that nature is a connected whole, and that accordingly no matter where the place may be from which we start, if we proceed systematically, with care and with wisdom, we shall gradually work our way onward, passing into subjects altogether new to us, finally reaching a satisfactory explanation of life and the destiny of the universe. And I claim that the road we shall travel will lead us through the field of chemistry directly into the unknown, and so I would claim for chemistry a first rank in the scheme of education.

THE PLANTING OF CHEMISTRY IN AMERICA.

BY RUFUS PHILLIPS WILLIAMS.

(Concluded from page 82.)

In the fall of 1810, the medical school was transferred to Boston, the first lectures being given in the house of Dr. Warren. But the connection with Cambridge was only partially severed, as it was provided that some lectures should be given at the college. This in later years became the cause of much vexation, for the same chemical apparatus was used to a large extent in lectures in both Cambridge and Boston, and every year it had to be carried over the Charles River from medical school to college, back and forth. This continued till 1858, when a separate professor was appointed for each institution. In the early years this transportation was not so irksome for the number of chemistry lectures given at the college was very small and the science formed but a minute part of the liberal education of a Harvard student during the first half of the 19th century.

In 1846 the medical school was transferred from Mason street, where it had been for more than thirty years, to a new building in North Grove street, and ultimately a chemical laboratory was constructed in the basement and fitted for 138 students. Each student had "his own place and his own apparatus for practical work in analysis and other chemical processes." This plan, so

universally adopted half a century later, was then a great innovation, but even here the laboratory was not used much for several years. Dr. John W. Webster was then professor of chemistry at both the medical school and the college, having been appointed in 1827 to succeed Dr. Gorham, as Erving professor of chemistry and mineralogy in Harvard. The year before his appointment, Webster wrote a voluminous, well illustrated text book of chemistry, which ran through three editions. His term of service of twenty-three years as professor was terminated by his resignation in 1850 and his execution the same year for the murder of Dr. Parkman nine months before. The amount of chemical knowledge obtained in those days may be inferred from the description of one of his lecture courses in the college. He "gave the class two or three chemical lectures, which were brought to a sudden end by his show experiment called *the volcano*—a large heap of sugar and potassium chlorate piled on a slab of soapstone. After he had lighted it with a drop of sulphuric acid, he saved himself by dodging out of the room and in a very few seconds all the members of the class found themselves obliged to jump out of the window." Professor Horsford later gave a voluntary course of three lectures. Such instruction after almost three-fourths of a century of chemistry in the college shows that science was not greatly fostered. In truth "chemical teaching in Harvard College had become extinct." The laboratory method invented by Liebig early in the century and introduced into the universities of Europe, was slow in being put into operation here. It was for Webster's successor, Josiah P. Cooke, to inaugurate this revolutionary change and to place chemistry on a par with classical studies.

When in 1848 Eben Horsford—a student under Liebig—was appointed professor of chemistry at the Lawrence Scientific School, just opened, he brought with him from Giessen the laboratory method of his illustrious master. The new building was at first entirely given up to chemistry and "a laboratory unsurpassed in Europe even at that time, for convenience for practical instruction, was erected and furnished." At practically the same time, Louis Agassiz was called to the chair of geology and zoölogy in the same institution. This was twenty-three years before the scientific school

became a part of the university, but both Agassiz and Horsford introduced a new system of teaching—instruction by the laboratory method—and in both cases the student was mainly thrown on his own resources. This method proved more successful in natural history than in chemistry. Professor Chandler, one of the pupils in 1853, describes the latter as follows: "There were about a dozen students in the laboratory, of whom half were beginners. We were given Will's Qualitative Analysis, and were set at work upon the 'hundred bottles'. After we had finished them, we began to make quantitative analyses, but we soon met a difficulty, which at that time prevailed generally in the United States; it was the lack of any systematic, organized course of study for the chemical profession. We were simply turned into the laboratory. There was no regular graded course of study, consisting of two, three or four years, including not only chemistry, theoretical, analytical and industrial, but other studies necessary to the young chemist. As a matter of fact, there were no lectures on chemistry at all for the students of the scientific school. We were expected to provide ourselves with text books and study them by ourselves at home." The number of students of science was small and all were special students. From its opening down to 1872, when it became a part of the university, degress in chemistry had been conferred on only 55 persons. Professor Horsford resigned in 1862 for the larger emoluments of manufacturing chemistry.

Among the young men who saw the volcano experiment, mentioned above, and made an exit through the nearest window, was one who was to take front rank in America among teachers and investigators in the science. The environment was not promising. But long before entering college he had done more experiments than were laid down in the curriculum. As a boy, Josiah Cooke had read that fascinating work of Mrs. Marcet, called *Conversations on Chemistry*—a book which for nearly half a century kept issuing from the press and stirred more youthful minds in England and America than perhaps any other chemistry ever written. Later, when Professor Silliman of Yale in 1840 gave a course of chemical lectures with experiments, at the Lowell Institute in Boston, Cooke was an earnest listener. At his Boston home he

improvised a laboratory, made and set up his own apparatus and repeated the Lowell Institute experiments with many others culled from Turner's Chemistry. The half dozen lectures during the college course did not profoundly add to knowledge obtained in this manner. And so we learn with some surprise that in 1849, the year after his graduation, he was appointed instructor in chemistry and mineralogy, and in 1850 was appointed to the chair made vacant by the hanging of Webster. He was then 23 years old, had had a teaching experience of little over a year and won the position in competition with David A. Wells, the afterwards distinguished political economist. The college had no apparatus and Cooke furnished what he used from his private laboratory. Then he went for a few months to Europe and bought apparatus and chemicals at his own expense for both medical school and college. The task was difficult. Science teaching was not favored by college faculties or overseers. There was a small lecture room but no laboratory. All that was required was a few lectures. But Cooke started a humble laboratory in a small basement room below his lecture hall and invited a few students to experiment with him. There was no running water nor gas. Charles W. Eliot, afterwards professor of chemistry at the Massachusetts Institute of Technology and now president of Harvard, was the first student admitted to this litfle first laboratory, and F. H. Storer, since eminent as an agricultural chemist, was another. Seven years later, laboratory work was made a requirement for college students studying chemistry. By 1853, Cooke had equipped the medical school in Boston so as to take a few pupils in qualitative analysis. "It is believed that this was the beginning in the United States of laboratory instruction in chemistry for medical students."

Professor Cooke was an indefatigable worker. His researches in atomic weight, classification of elements, specific gravity, mathematical crystallography, and in other lines, as well as his many publications, gave him an international reputation. His *New Chemistry,* first issued in 1874, was "translated into all the civilized languages of the globe." With all his attainments he was a self-made chemist, having "never worked for an hour in any laboratory but his own." For nearly half a century he was head of

the chemical department of Harvard. He saw it rise from almost nothing to one of the largest departments in the university; from a cellar corner to a large three-story granite building, now completely filled with laboratories and lecture rooms; from recitations of what others had done or might do to elaborate research in every branch of chemistry. "Professor Cooke created the Chemical and Mineralogical Department of Harvard University."

New Jersey.

The first professorship of chemistry at the College of New Jersey—now Princeton—was created October 1, 1795, and Dr. John Maclean was appointed to fill it. He was a young physician and chemist who had studied at Glasgow, London and Paris, and had come to America, locating in Princeton, where he was practicing medicine. Imbued with the theory of Lavoisier, it seems probable that he was its first teacher in this country. Before his appointment he had been invited to give a course of lectures on chemistry in the college. This course made such an impression on the faculty that at the very next meeting he was elected. It has been claimed that, aside from chairs of chemistry in the various medical schools of Philadelphia, New York and Cambridge, this was the first professorship in that science primarily for under-graduates, unless such professorship included natural philosophy or mathematics. The records of William and Mary College dispute this claim. Besides his lectures, Professor Maclean was allowed to continue to practice medicine, until the death of Dr. Minto, in 1797, at which time it was "ordered that chemistry and natural history be taught as branches of natural philosophy," and Maclean devoted his entire time to the college—this step being in accord with the usage of the times.

An account given by one Dr. Alexander of a visit to Princeton in 1801, was that "Dr. Maclean emigrated to America in 1795 and became one of the most popular professors who ever graced the college. He was at home almost equally in all branches of science. Chemistry, natural history, mathematics and natural philosophy successively claimed his attention." He was a native of Glasgow and entered the university in his thirteenth year. While a student there he and some of his companions formed a chemical society,

several of whose members afterwards rose to eminence. A book, *Lectures on Combustion,* which upheld the principles of Lavoisier as opposed to phlogiston, was from his pen, as were several papers in opposition to Priestley's views, published in the *New York Medical Repository.* Professor Silliman said of him: Dr. Maclean was a man of brilliant mind with all the acumen of his native Scotland, and a sparkling of wit gave variety to his conversation." In 1812 he resigned to accept a position elsewhere.

Connecticut.

The teaching of chemistry in Yale was not as an adjunct to medicine. For this reason it did not gain a foothold till the 19th century. In 1798 the president and fellows of Yale voted that a professorship of chemistry and natural history be instituted as soon as there were sufficient funds. It was four years ere the funds materialized. Benjamin Silliman was a graduate of the college, had been a tutor in it, and had finally settled upon the legal profession for a life work. There were scarcely any scientific books, there was no apparatus, and Silliman "had not learned the rudiments of science." But President Dwight's acumen saw in him a scientific diamond, and he finally persuaded him to abandon the law and accept the newly made chair of chemistry and natural history. The young professor in 1803 went to Philadelphia—almost the only place in America where he could study the subject to advantage—attended the lectures of Woodhouse and experimented together with his companion, Hare. On his way to the Quaker City he stopped at Princeton and made the acquaintance of Professor Maclean, of whom he afterwards said: "I regard him as my earliest master of chemistry, and Princeton as my first starting point in that pursuit, although I had not the opportunity to attend any lectures there." Years afterwards, while visiting the laboratory at Princeton, Professor Silliman remarked: "It was in this room that I saw the first experiments in chemistry ever witnessed by me." Next year he began lecturing to the students of Yale College, but, feeling his own deficiency in subjects of which he had set himself up to be master, he went abroad in 1805 and attended lectures mainly in London and Edinburg. After an absence of little over a year, he entered upon that brilliant

career in education and journalism which continued for half a century. Eminently a teacher and popularizer rather than a discoverer, he was "almost the father in this country of the three sciences in which he gave instruction. For many years the study of chemistry was the most popular one in college." The first third of the year was devoted to chemistry, the second to mineralogy, the last to geology. With an unusual assiduity he taught these subjects year after year with scarcely a break—except during one year of sickness—till 1851, when he took a second European trip. From 1835 to 1840 he gave popular lectures in many large cities from Boston to St. Louis and New Orleans. It was at one of these courses—the first lectures ever given at the Lowell Institute, January, 1840—that young Josiah Cooke gained the inspiration to follow science as a profession.

When Silliman entered upon his duties at Yale, there were "only minerals enough to fill a candle box," but he at once set about securing more, and finally after great effort he raised $20,000 and bought the Gibbs cabinet—then the best mineral collection in the United States.

Realizing the need of a periodical which should give the latest discoveries and inventions in science, especially in the three which he taught, he began in 1818 the publication of *Silliman's Journal*, afterwards called the *American Journal of Science*. Pecuniarily it was a losing venture, and for years the struggle for existence was severe, but it had been founded for science, not lucre, and it soon became the leading organ of its kind. In its pages for the major part of the century one can find the tabs of scientific progress. In 1830 he issued a text book of two octavo volumes. Here, in the history of education, the great teacher of chemistry in the college was the first one. For more than fifty years he was a member of the faculty, resigning in 1853, though he continued his lectures two years longer, his son being then appointed in his place.

New Hampshire.

It was more than quarter of a century after Wheelock in 1770 built the "log hut about eighteen feet square, without stone, brick, glass or nails," which formed the beginning of Dartmouth College,

that the first suggestion of a school of medicine was made. Dr. Nathan Smith in 1796 proposed to the trustees to give medical lectures to the students. Next year the lectures were given, and the following year a department of medicine was established by the election of Dr. Smith "Professor of Medicine." He was the veritable autocrat of that school, being clothed with the "power to employ assistants according to his wishes." The northwest corner of the lower floor of Dartmouth Hall was set apart for his use and constituted the medical school. The first course opened November 22, 1798. He selected as the lecturer on chemistry Dr. Lyman Spalding, a graduate of the Harvard school, class of 1797. Spalding evidently had been trained in the doctrine of Lavoisier, for we read that he had printed for his class "A New Nomenclature of Chemistry, proposed by De Morveau, Lavoisier, Berthollet and Fourcroy, with Additions and Improvements." Other lecturers on chemistry who followed Spalding were Rufus Graves, Esq., and Dr. Daniel Oliver, but there was no established chair until 1820. That year there was founded a "professorship of chemistry, mineralogy and the application of science to the arts." Dr. James F. Dana was appointed, who held the place for half a dozen years, and was succeeded in 1827 by Rev. Dr. Benjamin Hale, who—on account of espousing the Episcopal faith with too much ardor for the orthodox college—lost his position in 1835 by the abolition of the professorship, which, however, was restored next year, Dr. Oliver Payson Hubbard being appointed to the place. In Hale's valedictory letter to the trustees on the loss of his chair, one gets a spicy insight into the scientific apathy of the age. In it he says: "It is a remarkable fact that there is not one member of your board whose pursuits in life lead him to any acquaintance with physical studies, and I presume the importance absolute and relative of such studies is viewed by you as it stood in American colleges from thirty to fifty years ago when you were undergraduates. And your college feels the effect of this deficiency. It has not taken a scientific periodical, so far as I know, for half a century. The few that have crept into your library you owe to the charity of a pamphlet society which, through the influence of the late Professor Dana, among its other periodicals took one *Quarterly*.

Journal of Science, and at its decease bequeathed its collection to your library. Since its death, no report of the progress of science finds its way within your walls, save the *Journal* of Professor Silliman, taken by the two respectable societies among the students * * *" "A few years ago, no provision was made for chemical lectures to college classes, and members of the higher classes were in the habit of making a contract annually with my predecessor, Professor Dana, for the privilege of attending his lectures." Before Hale's advent, seniors were allowed to attend lectures on chemistry and anatomy on payment of $4 per year, juniors $2. Afterward seniors and juniors were allowed to attend the fourteen or fifteen weeks of daily lectures which Hale delivered to the "medics". Hale also had five or six weeks of daily recitation with the junior class, and gave to the undergraduate college students a separate course of thirty lectures per year. He established a course of twenty lectures in geology and mineralogy, and collected a cabinet of some 2,300 minerals where there were none before.

Dr. Hubbard, the successor of Hale, had one of the longest careers in the profession, his term as professor of chemistry in the Dartmouth Medical School lasting for forty-seven years, ending in 1883. Meantime, science in the college had been divorced from that in the medical school, each having its own chemical teacher.

Thus were planted in seven early institutions of learning in this country the seeds of that science which in little over a century has grown to enormous proportions. In tracing its origin and growth in these American centers, more space has been given to some because of the greater personality of the early educators and the more ample records available. Among all these men, three—Hare, Silliman and Cooke—pre-eminently distinguished themselves and gained a world-wide reputation.

Our research has shown that the first medical school in America was opened in 1765 in Philadelphia; that the first professorship of chemistry was established in 1767 in New York, with Samuel Smith as first professor; that the first professor of chemistry outside of a medical school was James Madison, of William

and Mary, in 1774; that the first teaching of anti-phlogiston (i. e. of Lavoisier's chemistry) was probably in 1795, at Princeton by Dr. John Maclean; that Dr. James Woodhouse of Philadelphia was the last man, 1809, to inculcate the phlogiston doctrine; that laboratory instruction was introduced in 1848 by Eben Horsford at the Lawrence Scientific School; that the earliest laboratory instruction in medical schools was given in 1853 by Professor J. P. Cooke, at the Harvard Medical School.

SHALL THE PREPARATION OF A HERBARIUM AND THE IDENTIFICATION OT SPECIES FORM A PART OF THE REQUIRED WORK IN BOTANY IN OUR SECONDARY SCHOOLS?

BY GILBERT H. TRAFTON.

Normal School, Randolph Center, Vt.

(*Concluded from page 94.*)

This very hurried survey of what the new botany offers is too fragmentary and brief to be called even an outline, and certainly does not do justice to the course as it may be carried out. But it may suggest, perhaps, the line along which the work proceeds. It hardly seems necessary to add that the very essence of ecology is the field work. No matter how commonplace the lesson to be taught or the object to be studied, it means far more to the student to see a plant growing in its natural surroundings than to see it only in the school room.

I now come to the last head under which I propose to speak of my subject, the stand of authorities on this question. In this time of individual religious freedom and rejection of any external, final authority, I would not seem to place botany on a less rational basis relying too much on the men who write our text books and conference reports. But as the majority of us who are teachers give instruction during the year in from five to fifteen subjects, and so are not able to deal exclusively with those subjects in which we are especially interested, it would seem fitting that we should

consider most carefully the suggestions of those who make a life work of teaching botany alone.

During the last three or four years, being especially interested in botany, I have taken opportunity to examine the better known botanical publications that have appeared since 1893, including text books, reports of committees and articles giving outlines for botany courses. At this time I will give you the results of a comparison of sixteen such publications, representing the opinions of about seventy-five botanists, including a large number of the best known botany teachers in our country. These publications include text books by Atkinson, Bailey, Barnes, Bergen, Bessey, Coulter, Ganong, Macbride, Pepoon, Spalding and Setchell, an outline by Lloyd, and the reports of four committees, that of the New York State Science Teachers' Association, of the Committee of Ten, of the Committee on College Entrance Requirements, and of the Committee appointed by the Society for Plant Morphology and Physiology.

At this point I will call your attention to the fact that I am balancing these authori'ies, not on the place to be assigned to special morphology in the half-year course, but on the question of the use of keys and the preparation of herbaria. For there are some who would retain the study of special morphology, though not by the methods just mentioned, but by a systematic study of families. But those who favor the retention of special morphology by any method form a very small minority. On the phase of the question that we have under discussion, however, the weight of authority is overwhelmingly in the negative, condemning the identification of species and the preparation of herbaria as a part of the required work in a half-year course, either directly when the matter is referred to or indirectly by excluding such work from the course outlined. Only two sanction the use of keys, Bailey and Bergen, and only one encourages the preparation of a herbarium, Bailey; but even then not in the aimless and indiscriminate way in which it is usually done, but with something definite in view to be illustrated by the collection. He says: "Too often the pupil thinks it sufficient merely to have made a collection, but the collection of itself is scarcely worth the while."

In thus showing the almost unanimous opinion of these authorities on this matter, perhaps it would seem that nothing more need be said, but I do wish, however, to call your attention to a few things in this connection. I have referred to Bergen as giving sanction to the use of keys, but yet he can hardly be said to encourage this work. Lest the fact that a key and flora has appeared in his new book should make his position misunderstood, I will quote from his "Foundations and Handbook." He says: "The author does not believe in spending much of the time of a class in identifying species. To him the analysis of flowering plants seems one of the least important of the many topics for study by a class in elementary botany." And again in his suggestions for a half-year course, he says: "Determine a very few species by aid of the Key and Flora, merely to illustrate the method." I have taken time to quote Bergen because his books are used quite extensively in New England and because the enlarged Key and Flora in his new book might seem to imply that he would assign an important place to the use of the Key, while he really lays but little stress upon it, as shown by the quotations which I have just read. But it should be borne in mind that Bergen's position in allowing a place for the key in a half-year course, even though it be but a very subordinate place, is not the position of the great majority of the authorities cited, who would allow no time whatever for such work.

My purpose in referring again to some of the other publications already mentioned is to emphasize the careful consideration which is their due, owing to the great weight of authority represented. I wish to call your attention in particular to the report of the committee appointed by the Society for Plant Morphology and Physiology. This committee, consisting of Ganong, Lloyd and Atkinson, was appointed at the meeting of the Society in December, 1900, to formulate a standard college-entrance option. A provisional report was made in the following April and a copy sent to each member of the Society with the understanding that it must receive the approval of a majority of the members before being completed, and that any suggestions made by a majority of them must be incorporated in the final report. This final report has been prepared and is the document to which I refer above. So this pub-

lication represents not merely the opinion of the three men on the committee but of a large majority of the members of the Society, for in this report is found the following: "The opinions called forth by the provisional report have displayed an almost unanimous approval of its main features, while the criticisms have been surprisingly few." The membership of this Society numbers about fifty-five and includes men who need no introduction to this Botanical Club, such as Professors Burt, Jones and Robinson, and other well known botanists of our country, as Atkinson, Bailey, Coulter, Farlow, Ganong, Goodale, Lloyd, MacDougall and Spalding. This report seems to me to be one of the most important documents to botany teachers published in the last decade.*

Lest the fact that the course here outlined is recommended for a college-entrance option would seem to make its bearing on our case less direct, I will suggest that as far as I know, our educators are practically unanimous in the opinion that there should be no difference in the treatment of the various subjects in our high-school curriculum for those going to college or scientific school, and those going to neither.

I wish to read that part of the report which refers to the methods of teaching botany that we are discussing. It reads as follows: "The ability to use Manuals for the determination of the species of flowering plants is not considered essential in this course, though it is desirable. It should not be introduced to the exclusion of any other work, but may well be made voluntary work for those showing a taste for it. It should not be limited to learning names of plants, but should be made a study in the plan of classification as well. The preparation of a herbarium is not required nor recommended except as voluntary work for those with a taste for collecting. If made, it should not constitute a simple accumulation of species, but should represent some distinct idea of

*This report in its official form is printed elsewhere in this number of SCHOOL SCIENCE (Pages 159-165), the first appearance of the third edition. Its publication here will be the more welcome to our readers, inasmuch as the recent formal adoption of the course it recommends by the College Entrance Examination Board makes it the official entrance option for all the leading universities and colleges of the Middle States and Maryland accepting Botany for entrance, and for many of those of the neighboring states. The example of these institutions, together with the very wide approval it has received from prominent teachers, is likely to lead to its general adoption in this country as a standard course for high schools and for entrance to college.—EDITOR.

plant associations, of morphology, of representation of the Groups, etc."

Thus the position of the report in not recommending either the use of keys or the preparation of herbaria as required work is clear. But there is still one other very important point to be noted. Even when this work is done voluntarily, this report would place it at the end of the full year course and not in connection with the half year course. As far as our Vermont problem is concerned, then, where we give but a half year or less to botany, this report leaves no place whatever for the key and the herbarium, even as voluntary work.

The three points which I have tried to emphasize with reference to the key and the herbarium as required work in our short courses are, first, that they are not justified by the results which they yield, second, that the new botany has something to offer in their place which is far superior, and third, that those authorities who have expressed themselves on the matter either directly or indirectly, are almost unanimously opposed to these methods.

As helpful text books which embody the modern spirit I would suggest Bergen's "Foundations of Botany," without the Key and Flora, Atkinson's "Lessons in Botany," and Coulter's "Plants," more especially the first for gross morphology, the second for physiology, and the third for ecology. For a clear and detailed treatment of the whole subject of botany teaching, I recommend most heartily and without reserve Ganong's "Teaching Botanist." No teacher of botany can afford to be without a copy.

And, lastly, of those here who are not teachers I would beg that they foster the better spirit of botany teaching, at least in the negative way, by not implying that a student's knowledge of botany is to be measured by his ability to name the common plants.

THE DUTY OF THE UNIVERSITY TO THE SECONDARY SCHOOL TEACHER OF PHYSIOLOGY AND HYGIENE.

BY W. H. MANWARING.

Johns Hopkins Medical School.

Formerly Professor of Physiology and Hygiene, State Normal School, Winona, Minn.

Thirty years ago, the teaching of physics and chemistry in our high schools and academies was almost exclusively by the text-book method. During the last quarter century, there has been introduced in these sciences class-room demonstrations by the teacher, and, later, laboratory exercises by the pupil. There has resulted a universal knowledge of the value of such demonstration and laboratory work, so that, today, no sane teacher would attempt either subject without using both.

The introduction of scientific methods in the teaching of high-school botany and zoölogy is of more recent date. Even today, real laboratory methods are not used in more than a bare majority of schools. There is, however, a widespread belief that either subject, without laboratory instruction, is sterile and worthless. Our universities are each year turning out graduates better prepared to direct such work and more thoroughly convinced of its value, and we may look, in the near future, for its wider use.

While the teaching of physics, chemistry and zoölogy has been so greatly improved, the teaching of physiology and hygiene is almost where it was a half-century ago. It is safe to say that in 95 per cent of the high schools the teaching is by the old text-book method exclusively, that in but few is real demonstration work attempted, and that in not more than a score is laboratory work required. Still physiology and hygiene, even more than chemistry, is barren and worthless without this practical work.

For a number of years, the leaders in educational movements have recognized the uselessness of mere text-book instruction in thus subject, and have endeavored to secure a wider adoption of laboratory methods. Their efforts, however, have been attended with scant success.

The reason for this is the difficulty they have had in obtaining teachers prepared to use the newer method. Teachers now in service are, with rare exceptions, lacking in the practical training necessary for this work, and, under the present arrangement of university studies, they have no opportunity of obtaining such training without undue sacrifice of time and money. For the salaries paid in the majority of schools, it seems impossible to obtain recent graduates who have had a laboratory training in the large number of subjects that specialization in university work renders necessary for this work.

Under the existing system of university teaching, if a graduate has not had a laboratory training in anatomy, histology, embryology, bacteriology, pathology, and physiological chemistry, in addition to his preparation in pure physiology, physics, chemistry, and general biology, he is not prepared to undertake with success modern instruction in elementary physiology and hygiene. A university training in pure physiology is not sufficient. First, because the work in the secondary school is not work in pure physiology at all, but is properly a combination of the rudiments of all of the preliminary medical sciences. Second, because the department of physiology in our universities is usually in the hands of a specialist in some one particular subdivision of pure physiology, who is generally not interested in secondary schools, who is always out of touch with them and their methods, and who is usually even out of sympathy with them and their aims.

Teachers, however, could be prepared for this work in a very short time, if our universities would offer a well systematized Teachers' Course in Elementary Anatomy, Physiology, and Hygiene. Such a course should consist of laboratory instruction in those elements of the various subjects mentioned above that it is necessary the secondary teacher should know, together with lectures on the pedagogical and scientific sides of the subject. The course should be systematic and thorough. Above all, it must be given by a man in direct touch with secondary schools and of broad understanding of their aims and needs.

Such a course should be planned to meet the needs of two classes of students; first, university seniors who are preparing to teach in secondary schools; second, and most important, high-

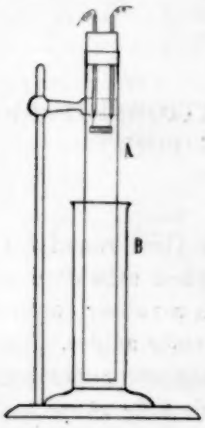
school teachers now in service who have not had a training in laboratory methods. It should be given during the summer months so that both could profit by it. Should such a course be offered by any one of our prominent summer schools, as that of the University of Chicago, or of Harvard University, it would be largely attended.

There is great need for work along this line. The wide-awake school men know this and the superintendents are anxious for it. It only remains to be seen how long it will take the universities to realize this fact and act accordingly.

A METHOD OF DETERMINING THE RELATIVE AMOUNTS OF OXYGEN AND NITROGEN IN THE ATMOSPHERE.

BY GEORGE C. ASHMAN,
Department of Chemistry, Bradley Polytechnic Institute, Peoria, Ill.

Mr. Sparling, a student in this laboratory, and myself have devised the following method for determining the relative amounts of oxygen and nitrogen in the atmosphere. *A* is a tube of hard glass, 30 cm. in length and 25 mm. in diameter, open at both ends.



The upper end of the tube is closed by a tightly-fitting, two-hole rubber stopper which carries two small glass tubes with heavy platinum wires sealed into their lower ends. These wires support a coil of about ten turns of small platinum wire. This coil carries a piece of charcoal of convenient size.

After the stopper with the tubes, the coil and the charcoal has been placed in position, the upper portion of the tube *A* is graduated into six equal divisions of about 20 cc. each.

B is a cylinder partly filled with mercury. By removing the stopper five divisions of the tube *A* can be filled with air and se-

curely closed at the atmospheric pressure by again tightly fixing the stopper.

The small glass tubes are partly filled with mercury, and by this means electrical contact is made.

The current is turned on slowly at first, but the coil is finally brought to bright redness. If 100 cc. of air are used the coil should be maintained at a bright red heat for thirty minutes. During the burning and subsequent cooling the pressure is maintained constant by adjusting the inner tube.

When the current is turned off and the gas has recovered the temperature of the room, it is found to occupy six divisions of the tube *A*.

The oxygen has united with the carbon to form carbon monoxide, and as one volume of oxygen yields two volumes of carbon monoxide, it is obvious that the oxygen originally contained in the air occupied a volume equal to one of the divisions of the tube.

The experiment is a very satisfactory one for lecture demonstration, especially if the students have previously studied the oxides of carbon.

The charcoal used must first be heated to redness in a stream of chlorine to free it of all absorbed gases.

AN EXPERIMENT SHOWING THE RELATIONSHIP BETWEEN PRESSURE AND BOILING POINT.

BY C. E. LINEBARGER.

The apparatus (Fig. 1) consists of a flask (best round bottomed, as flat bottomed ones sometimes burst when exhausted of air) of from 200 to 500 cc. capacity, fitted with a rubber stopper through which passes a glass tube bent twice at right angles. The longer branch (80cms.) dips in a vessel containing some mercury. The flask is supported by means of a ring with wire gauze and clamp on a retort stand.

The flask is filled about a third full of water to which a pinch of some fine, insoluble powder, as powdered marble or precipitated

silica, is added. Some hydrant waters, when boiled, have a sediment separate out which answers very well. Water which is entirely free from finely divided particles does not boil easily and regularly, and does not illustrate the point in question as well as a water holding solid matter in suspension.

The water is heated to boiling and as soon as the escaping

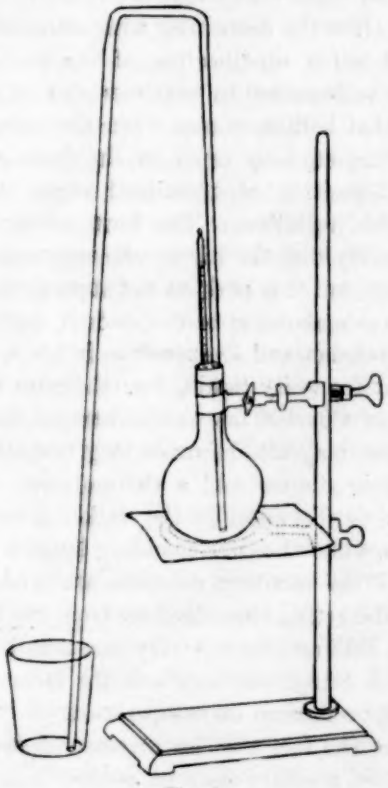


Fig. 1

steam causes crackling reports as it passes into the mercury (evidence of the complete expulsion of the air), the flame is removed.

Usually as the flask cools off, the boiling continues and the mercury rises with an oscillating motion. If, however, the solid nuclei are not of the right nature, the boiling ceases and the mer-

cury rises steadily. That vapor is given off in both cases may be seen from its condensing in the tube and either running back into the flask or collecting over the mercury in the longer branch.

If a stream of water (from a wash bottle) be played over the flask, the water in it boils vigorously and the mercury oscillates, falling when a bubble of steam is formed, but rising again at once; and it is to be noted particularly that the mercury is always finally at a higher level after the drenching with water than before.

The above is but a modification of the so-called Franklin's experiment which is described in nearly every text book of physics.

The reason that boiling ensues when the outside of the flask is cooled is that the aqueous vapor in the flask is partially condensed and the formation of additional vapor thereby rendered possible, with a boiling effect. The form of apparatus just described shows directly that the higher the temperature, the greater the aqueous tension, but it is perhaps not superfluous to caution the teacher to be sure to make clear to the student that the relationship between aqueous tension and temperature is not a simple one and that it is different for every liquid, for otherwise the student may think that a sort of Charles' law can be here applied.

This apparatus may also be made to give quantitative results, by using a two-hole stopper and a thermometer whose bulb dips below the surface of the water in the flask. A series of readings of the temperatures and the corresponding lengths (measured with a meter stick) of the mercury columns are made and the pressures found by subtracting these lengths from the barometric reading. The results obtained are not very accurate, but when plotted, give a curve which brings out very well the facts in regard to the dependence of vapor tension on temperature.

To emphasize the fact that an increase of pressure raises the boiling point, more mercury may be poured into the cylinder so that the steam has to overcome the added pressure of the mercury in order to escape. The water should be made to boil vigorously and the temperature read from the thermometer after each addition of a small portion of mercury (enough to raise the level of the liquid metal 2 or 3 cm.). The stopper should be wired in, and it is perhaps not safe to raise the boiling point above 105°.

THIRD REPORT

of a Committee Appointed by

THE SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY,

AT BALTIMORE, DECEMBER 28, 1900,

to Consider the Formulation of

A STANDARD COLLEGE ENTRANCE OPTION IN BOTANY.

The present report is based upon the Revised Report issued in September, 1901. It contains some alterations suggested by the communications received by the Committee in response to a request for comments and criticisms upon the earlier editions, but the changes are few and unimportant. They consist chiefly in the addition of Principle 5 and some verbal changes intended to call attention more prominently to the possibility of making the study of the Groups (of Part II.) the principal part of the course, the topics of Part I. being incorporated at appropriate places therein. This has always been admitted as a possibility by the option, but it is only fair to say that it seems to the Committee a less advantageous arrangement than that here recommended, and one from which, and not towards which, educational opinion is trending.

The full year option here recommended was formally adopted by the College Entrance Examination Board (formerly of the Middle States and Maryland) in December, 1901, and appears in their Document No. 8, issued January 10, 1902. Examinations will be held in it for the first time in June, 1902.

The Society for Plant Morphology and Physiology, at its meeting in New York on January 1, 1902, voted to place the option in the hands of a permanent committee, which should be charged to make it as useful, educationally, as possible, and to keep it in touch with changing educational conditions. The former Committee was continued as the permanent Committee.

The Committee:

W. F. GANONG, Smith College, Northampton, Mass.

F. E. LLOYD, Teachers' College, Columbia University, New York.

April 15, 1902.

OUTLINE OF THE PROPOSED OPTION.

(It may be known briefly as The Standard Option.)

PRINCIPLES UPON WHICH THE COURSE IS FORMULATED.

1. It is founded upon the two important Reports of the National Educational Association,—the "Report of the Committee of Ten" (Washington, 1893), and the Report on College Entrance Requirements (Chicago, 1899).
2. It is intended primarily as an option for entrance to College, but equally for the education in the high school of the general student who can follow the subject no farther; there are in Botany no advantages in having the college preparatory and the general educational courses different, at least none that are at all commensurate with the additional burden thus laid upon the schools.
3. It should, if possible, be founded upon a considerable body of botanical fact learned through "Nature Study" in the lower schools; it should form part of a four years' high school course in the Sciences; it should be considered and treated as an elementary or preliminary course leading to second courses in College, and Colleges accepting the option should make provision to articulate second courses economically with it.
4. The immediate plan of its construction is very simple, namely, to include those topics in the leading divisions of the subject which most teachers now regard as fundamental, either for their value in scientific training, or as knowledge; but the individual teacher is left free to follow his own judgment as to sequence of topics, text and other books, and special methods. Advice is occasionally offered, however, upon important points in which most teachers are now known to agree.
5. It recognizes the existence of, and provides for, two modes of procedure in the sequence of topics. In one, that here advised, the general principles of plant structure and function, permitting a beginning with large and familiar objects and phenomena, are first studied, to be followed later by a study of representatives of the Groups of Plants from the lower to the higher; the other makes the study of the Groups the backbone, as it were, of the course, beginning with the lowest forms and introducing the physiological and morphological topics at appropriate places in the ascending series. The two modes, however, lead to substantially the same result, and a common examination is practicable for both.
6. It is designed to yield a mental discipline fully equal in quality and quantity to that yielded by any other subject studied for the same length of time.

7. The time per week, inclusive of recitation, preparation, and laboratory should be the same as for any other subject. Where five periods a week with an hour of preparation for each are demanded for other studies, this course should receive the equivalent of two recitation periods with their preparation, together with three double (not six separated) periods in the laboratory and a small amount of outside related work or preparation. Variation from this should be towards a greater, not a lesser proportion of laboratory work. The preparation of records of the laboratory work, in which stress is laid upon diagrammatically accurate drawing and precise and expressive description, is regarded as an integral part of the course; and these records, preferably in a note-book, must be presented with the examination-paper, and will count one-third towards admission.

8. There must be provided,—
   (*a*) A full year option.
   (*b*) A half year option.
   (*c*) The possibility of a two-years' option.

SPECIFICATIONS.

The *full year option*, to count as 1 unit or point out of 13 to 15 for entrance, will consist of:—

(I.) A half year devoted to the General Principles of Anatomy, Morphology, Physiology and Ecology.

(II.) A half year devoted to the Natural History of the Plant Groups, with Classification.

The full year option may consist, also, of II. enlarged to occupy a year and including the essentials of I. (See Principle 5 above.)

The *half year option*, to count as 1 unit or point out of 26 to 30 for entrance, may consist of either I or II above, but not of a composite of both.

A half-year option consisting of a composite of I and II, although recognized as profitable under some local conditions, is not here included; since, while it is not considered educationally superior, if equal, to I or II more thoroughly studied, it will be impossible for colleges to make arrangements to articulate it profitably with their higher courses in addition to I and II; and, moreover, Examination Boards will find obvious difficulties in providing examinations for it.

The *two years option* will consist of I enlarged to a year, together with II enlarged to a year.

I. The half year option in the General Principles of Anatomy, Morphology, Physiology and Ecology.

The fundamental topics are the following:—

A. In Anatomy and Morphology.

The Seed. Four types (dicotyledon without and with endosperm, a monocotyledon and a gymnosperm); structure and homologous parts.

Food supply; experimental determination of its nature and value. Phenomena of germination and growth of embryo into a seedling (including bursting from the seed, assumption of position and unfolding of parts).

The Shoot. Gross anatomy of a typical shoot; including the relationships of position of leaf, stem (and root), the arrangement of leaves and buds on the stem, and deviations (through light adjustment, etc.) from symmetry.

Buds, and the mode of origin of new leaf and stem; winter buds in particular.

Specialized and metamorphosed shoots (stems and leaves). General structure and distribution of the leading tissues of the shoot; annual growth; shedding of bark and leaves.

The Root. Gross anatomy of a typical root; position and origin of secondary roots; hair-zone, cap and growing-point. Specialized and metamorphosed roots. General structure and distribution of the leading tissues of the root.

The Flower. Structure of a typical flower, especially of ovule and pollen; functions of the parts. Comparative morphological study of six or more different marked types, with the construction of transverse and longitudinal diagrams.

The Fruit. Structure of a typical fruit, especially with reference to changes from the flower, and from ovule to seed. Comparative morphological study of six or more marked types, with diagrams.

This comparative morphological study of flowers and fruits may advantageously be postponed to the end of II, and then taken up in connection with Classification of the Angiosperms.

The Cell. Cytoplasm, Nucleus, Sap-cavity, Wall. Adaptive modifications of walls, formation of tissues.

As to the study of the cell, it is by no means to be postponed for consideration by itself after the other topics, as its position in the above outline may seem to imply, but it is to be brought in earlier along with the study of the Shoot or Root, and continued from topic to topic. Although enough study of the individual cell is to be made to give an idea of its structure (a study which may very advantageously be associated with the physiological topics first mentioned under B), the principal microscopical work should consist in the recognition and study of the distribution of the leading tissues.

B. In Physiology.

Role of water in the plant; *absorption (osmosis), path of transfer, transpiration, turgidity and its mechanical value, plasmolysis.*

Photosynthesis; *Dependence of starch formation upon chlorophyll, light and carbon dioxide; evolution of oxygen,* observation of starch grains.

Respiration; *necessity for oxygen in growth, evolution of carbon dioxide.*

Digestion; *Digestion of starch with diastase,* and its role in translocation of foods.

Irritability; *Geotropism, heliotropism* and *hydrotropism;* nature of stimulus and response.

Growth; *localization in higher plants; amount in germinating seeds and stems; relationships to temperature.*

Fertilization; sexual and vegetative reproduction.

Although for convenience of reference, the physiological topics are here grouped together, they should by no means be studied by themselves and apart from anatomy and morphology. On the contrary, they should be taken up along with the study of the structures in which the processes occur, and which they help to explain; thus,—photosynthesis should be studied with the leaf, as should also transpiration, while digestion may best come with germination, osmotic absorption with the root, and so on. The student should either try, or at least aid in trying, experiments to demonstrate the fundamental processes indicated above in italics.

C. In Ecology.

Modifications (metamorphoses) of parts for special functions.
Dissemination.
Cross-pollination.
Light relations of green tissues; leaf mosaics.
Plant Societies; Mesophytes, Hydrophytes, Halophytes, Xerophytes; Climbers, Epiphytes, Parasites (and Saprophytes), Insectivora.
Plant Associations, and zonal distribution.

The topics in Ecology, (particularly the first four and in part the fifth) like those in Physiology, are to be studied not by themselves, but along with the structures with which they are most closely connected, as cross-pollination with the flower, dissemination with the seed, etc. The fifth and sixth may most advantageously be studied with G in Part II.

In this connection field-work is of great importance, and for some topics, such as the sixth, is indispensable, though much may be done also with potted plants in greenhouses, photographs, and museum specimens. It is strongly recommended that some systematic field-work be considered as an integral part of the course, coördinate in definiteness and value as far as it goes with the laboratory work. The temptations to haziness and guessing in Ecology must be combated.

II. The half year option in the Natural History of the Plant Groups and Classification.

A comprehensive summary of the great natural groups of plants, based upon the thorough study of the structure, reproduction and adaptations to habitat of one or two types from each group, supplemented and extended by more rapid study of other forms in those groups. Where living material is wanting for the latter, preserved material and even good pictures may be used, and a standard text-book should be thoroughly read. The general homologies from group to group should be understood.

In general, in this part of the course, it is recommended that much less attention be given to the lower and inconspicuous groups, and progressively more to the higher and conspicuous forms.

Following is a list of recommended types from which, or their equivalents, selection may be made:

A. Algae. Pleurococcus, Sphaerella, Spirogyra, Vaucheria, Fucus, Nemalion (or Batrachospermum or Polysiphonia or Coleochaete).

B. Fungi. Bacteria, Rhizopus, Yeast, Puccinia (or any Powdery Mildew), Mushroom.

Bacteria and Yeast have obvious disadvantages in such a course, but their great economic prominence may justify their introduction.

C. Lichens. Physcia (or Parmelia).

D. Bryophytes. In Hepaticae, Radula (or Porella or Marchantia). In Musci, Mnium (or Funaria or Polytrichum).

E. Pteridophytes. In Filicineae, Aspidium or equivalent, including, of course, the prothallus.
In Equisetineae, Equisetum.
In Lycopodineae, Lycopodium and Selaginella (or Isoetes).

F. Gymnosperms. Pinus or equivalent.

G. Angiosperms. A monocotyledon and a dicotyledon, to be studied with reference to the homologies of their parts with those in the above groups; together with representative plants of the leading subdivisions and principal families of Angiosperms.

Classification should include a study of the primary subdivisions of the above groups, based on the comparison of the types with other (preferably) living or preserved material. The principal subdivisions of the Angiosperms, grouped on the Engler and Prantl System, should be understood.

The ability to use Manuals for the determination of the species of flowering plants is not considered essential in this course, though it is desirable. It should not be introduced to the exclusion of any other work, but may well be made voluntary work for those showing a taste for it. It should not be limited to learning names of plants, but should be made a study in the plan of classification as well.

The preparation of an herbarium is not required nor recommended except as voluntary work for those with a taste for collecting. If made, it should not constitute a simple accumulation of species, but should represent some distinct idea of plant associations, or of morphology, or of representation of the Groups, etc.

PLANS FOR A BIOLOGICAL LABORATORY.

BY S. O. MAST,
Professor of Biology, Hope College, Hol and, Mich.

The plans here presented were drafted for a biological laboratory in process of construction at Hope College, Holland, Mich.

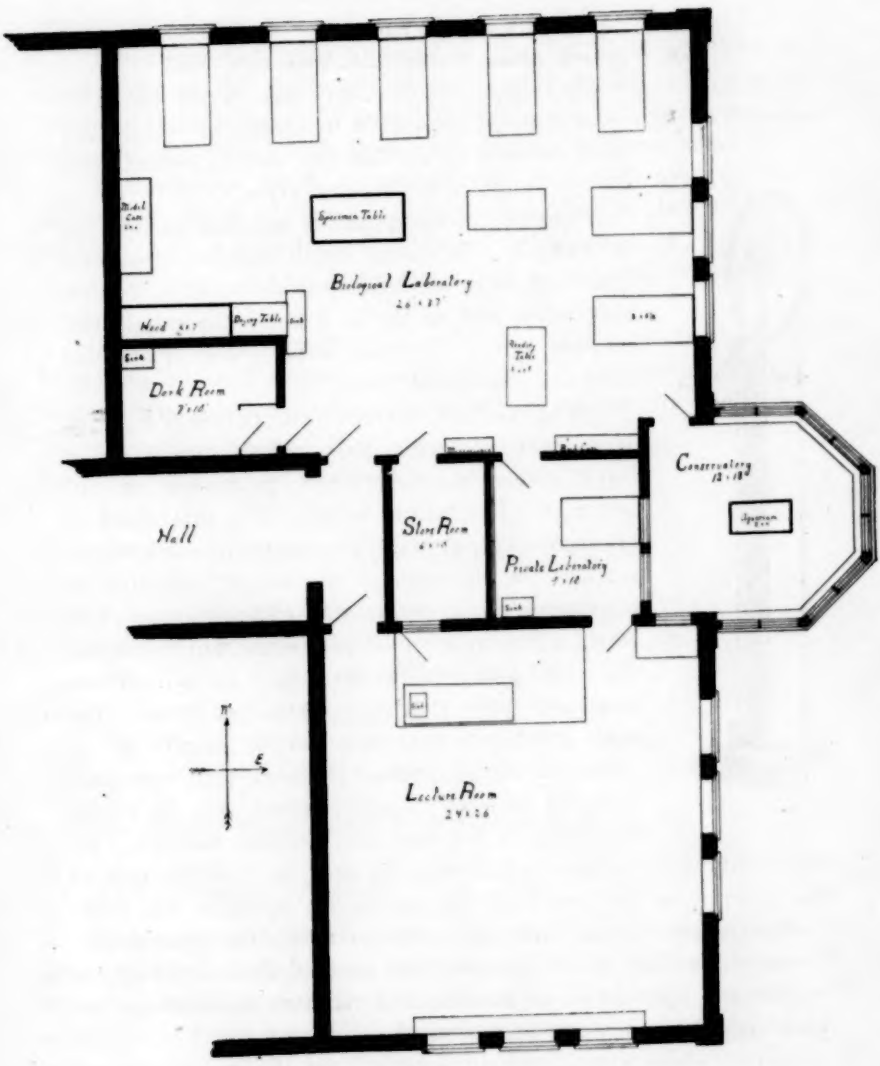
The laboratory will occupy the entire east end of the second floor, and in order to avoid direct sunlight as much as possible, will face the north. It is to accommodate twenty-eight students, four at each of the seven working tables. These tables will be supplied with four drawers on either side. The drawers will be arranged one above the other in the middle of the tables. Adjustable swivel chairs with backs will be used at the tables.

There is a conservatory for plants, with glass roof and sides, and a cement floor connected with the sewer system by a drain. The dark room is to be used both for performing physiological experiments in the absence of light and for work in photography. The store room will accommodate not only biological material, but also chemical glassware, stains, etc. A hood which will accommodate three students at one time is supplied with water and gas.

The lecture room will seat forty. It is adapted for demonstrations as well as quizzes and lectures, being in close connection with the store room, the private and the general laboratories.

We have planned a private laboratory, 9x12 feet—rather small, but better than none. As it is lighted only through the conservatory, it is supplied with both gas and electricity. Every instructor should do some special work. This does not necessarily mean that every instructor should be an original investigator; he should be a teacher first of all. The special work he does may be the preparation of material in new ways for student use, or the working over of old experiments. Such a room, where the instructor may work undisturbed by the thoughtlessness of students, will also give them a wholesome notion of the difference between private and public laboratory belongings.

*Presented before the joint session of the Biological section of the Michigan School Masters' Club and the Michigan Academy of Sciences at Ann Arbor, Mich. (See report of this meeting, page 188.)


Specimen Table
Biological Laboratory
26 × 37
Dark Room
7 × 10
Hall
Slow Room
Private Laboratory
7 × 10
Conservatory
13 × 18
Lecture Room
29 × 26
N
E

A FALLING BODY MACHINE.

BY A. L. EWING.

Dept. of Natural Science, Normal School, River Falls, Wis.

It has been my privilege this year to place in the hands of students in physics a piece of apparatus by means of which they could determine the laws of falling bodies with only a small percentage of error.

The pupils operated the machine themselves, individually, following brief printed directions. The topic was not discussed previous to laboratory work, and so far as I know the pupils had no idea of the laws they were in search of until they had discovered them.

The machine, invented and patented by J. S. Heminway of River Falls, Wis., consists of a light, nicely balanced wheel, journaled on ball bearings. The falling weight turns this wheel by an unwinding string. The wheel can be accurately set and the elevation of the weight indicated by a marker on a brass rod. The operator now starts a heavy, seconds' pendulum which releases the wheel and permits the weight to fall. There is a light index that moves with the wheel. The same pendulum that released the weight, by an ingenious device, causes this index to stop suddenly at the end of any interval, 1st, 2d or 3d, according to the way the machine was set. By now stopping the wheel and turning it back, so that the zero of the wheel is at the point of the index, the operator can place another marker to indicate the point to which the weight fell. When he has thus found the positions reached at the end of the 1st, 2d and 3d second, he removes the rod to a table where the intervals may be accurately measured.

The pupils were directed to find the ratio, to the nearest integer, between the distance the weight traversed during the first interval and the two intervals, then during the first and

the three intervals, and report percentage of error. They all derived the first, fourth and ninth with errors, falling short, approximately 2 per cent.

For velocity, a table attached to the rod is so adjusted as to stop the weight at the end of the desired second. The string unwound during the next second indicates the velocity at end of the given second. Errors here were similar to those above.

The machine is of convenient size to be operated by one standing on the floor, is adapted to the handling of inexperienced students, and is readily comprehended. The piece of apparatus is not expensive, so that laboratories may be supplied with duplicates.

This piece of apparatus was exhibited at the meeting of the Wisconsin State Teachers' Association, held at Milwaukee last winter. The numerous comments on it were universally favorable.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(*Continued from page 110.*)

Experiment XXXIV.

To find the distance from the earth to the sun.

(a) *By Aristotle's method.*

Note the length of the interval of time from new moon to first quarter as indicated by the straightness of the terminator. Knowing then the length of the lunation, 29.53 days (synodic month, time from new moon to new moon again), and that the moon moves through 360° during this lunation, the angular velocity of the moon, and hence the angle $S\,E\,M$, is obtained. The angle at M being right (90°) at this instant, a small right triangle

may be constructed on paper having any convenient length for $M\,E$ (which represents the distance to the moon found in the last experiment), and the known values for $S\,M\,E$ and $M\,E\,S$, from which the length of the hypothenuse may be read to the scale on which $M\,E$ represents the lunar distance. The hypothenuse so expressed will represent the distance to the sun.

Using times of new moon and first quarter from a common

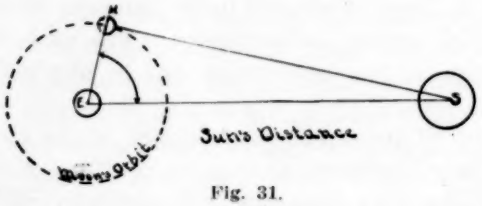


Fig. 31.

patent medicine almanac, and 238,000 miles for the lunar distance, find the sun's distance. Solve the problem both geometrically and trigonometrically if you can.

(b) *Geometrical methods by transits of Venus* will be given after the method of finding relative planetary distances is developed.

Experiment XXXV.

To find distances from sun to Mercury and Venus in terms of earth's distance from the sun.

The earth, E, and Venus (the method will be seen to apply to Mercury also), V, revolve round the sun, S, in the same directions, the earth moving more slowly. When Venus comes into line with the earth and sun, as at $V1$, we say the planet is in *inferior conjunction*, and when it is at $V3$ it is said to be in *superior conjunction*. When the planet has swung out its farthest from the sun, as at $V2$ or $V4$, it is said to be at *greatest elongation, eastern or western*. Note that at this instant the angle at the planet in the triangle $S\,V2\,E$, or $S\,V4\,E$, is right. The angle

at E may be measured directly, or it may be obtained from a common almanac. Then assuming any desired scale for $S\,E$, a right triangle may be constructed on paper, having the angles E and S $(=90°—E)$ at the ends of $S\,E$. $S\,V2$, or $S\,V4$, will then denote the required distance. It may be measured by noting the mean time when Venus (or Mercury) crosses the meridian, and then converting the time interval into angle by multiplying the hours, minutes, and seconds by 15.

When $S\,E$ is known, $S\,V$ may be stated in miles. This same

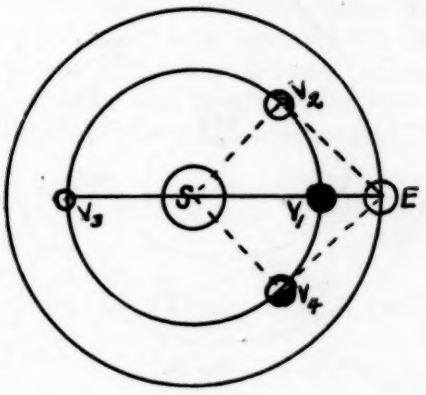


Fig. 32.

method holds good for either Mercury or Venus; but for no other planets.

Solve this problem both geometrically, by drawing to scale, and trigonometrically, using data of almanac.

Experiment XXXVI.

To find distance from sun to Mars, or to any planet whose orbit lies beyond that of the earth.

(The period of revolution of Mars is supposed to be known. Call it 687 days.) This may be found as for Moon Exp. XV.

At any instant measure the angle $S\,E1\,M$ at the earth between

the sun and Mars. Six hundred and eighty-seven days afterward Mars will be in the same place again, but the earth will have moved around twice, lacking 43.5 ($2 \times 365.25 - 687$) days. Measure the angle $S\ E_1\ M$ at this time, and remembering that the earth moves over $360° \div 365\frac{1}{4}$ daily, we have only to multiply this by equal and known, a quadrilateral may be readily drawn to scale,

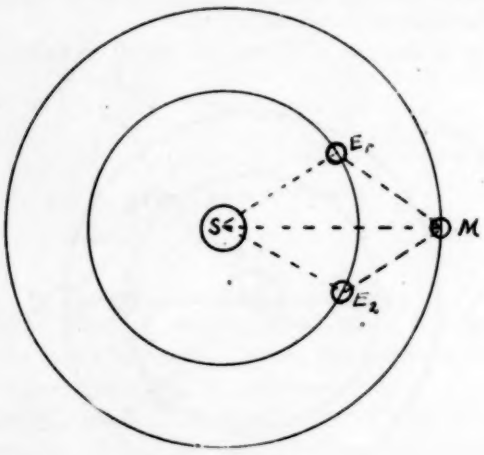


Fig. 33.

from which the straight line $M\ S$ may be read. Obviously, this process is applicable to any planet beyond the earth, as soon as its period is known, and this may be obtained by direct observation, as we hope to show later. Using observed data, or data of the *Ephemeris,* compute the distance from Mars to sun, and do same for other planets.

[NOTE: The last two experiments show how the distances of all the planets are made to depend upon the earth's distance by the simple geometric treatment of observational data. It is with the hope of getting the earth's distance more accurately than ever before that astronomers are giving so much work just now to the little planet called Eros. Whatever error remains in the earth's distance vitiates all other distances and dimensions, not only in the solar system, but throughout the stellar universe.]

Experiment XXXVII.

To find the distance from the sun to a star.

Let S represent the sun and $E1\ M\ E2\ N$ the orbit of the earth. Let B denote the position of a star, say of Alpha Centauri. On a certain date the star B seen from $E1$ would be projected on the sky among the stars $C\ D\ E\ F$. Six months later the earth has been carried in its annual journey to $E2$ (186,000,000 miles from $E1$), and star B is then seen projected among the stars $G\ H\ J\ K$. This apparent displacement is measured by the arc xy, or by the angle $x\ By = E1\ B\ E2$, and it is obviously due to the observer's 186,000,000-mile shift of position in space, and not to any real change of position of the star B. If an observer were supposed to be on B and looking toward the earth, and the line $E1\ E2$ were

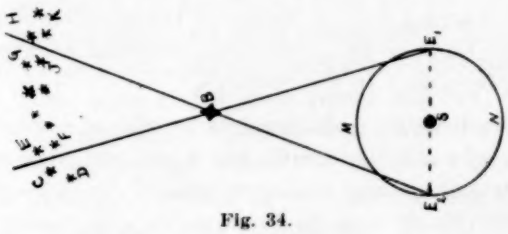


Fig. 34.

visible to him, we might say the angle $E1\ B\ E2$ is the apparent angular diameter of the earth's orbit.

Now Experiment VII. taught us the law connecting the apparent angular dimensions of a line with its distance from the observer. Further experimenting would show us that if an object is viewed at a distance of 206,265 times its own dimensions it would open up an angle of one second of arc at the observer's eye. Experiment VII. shows that the apparent angle varies inversely as the distance. If the apparent angle is half a second, the object is 2x206,265 times its own dimensions from the observer, etc. Half of this angle $E1\ B\ E2$ is called the star's *parallax*.

(To be continued.)

Metrology.

THE NATIONAL BUREAU OF STANDARDS.

BY RUFUS P. WILLIAMS.

(*Concluded from page 114.*)

(2) It is perhaps enough to say of barometers that all standardizing has to be done abroad, as in the case of thermometers.

(3) In many instruments an accurate standard is of great financial importance as well to government as to corporations. The annual duty on sugar, for example, amounts to some $60,000,000 and is based on the reading of the polariscope, an error of one-tenth of one per cent in the readings making a difference of $60,000 on the duty. A suit against the government has been pending for a long time. It hinges on the question of polariscopic reading, and there is no government standard to which to refer the quartz plates used in the readings.

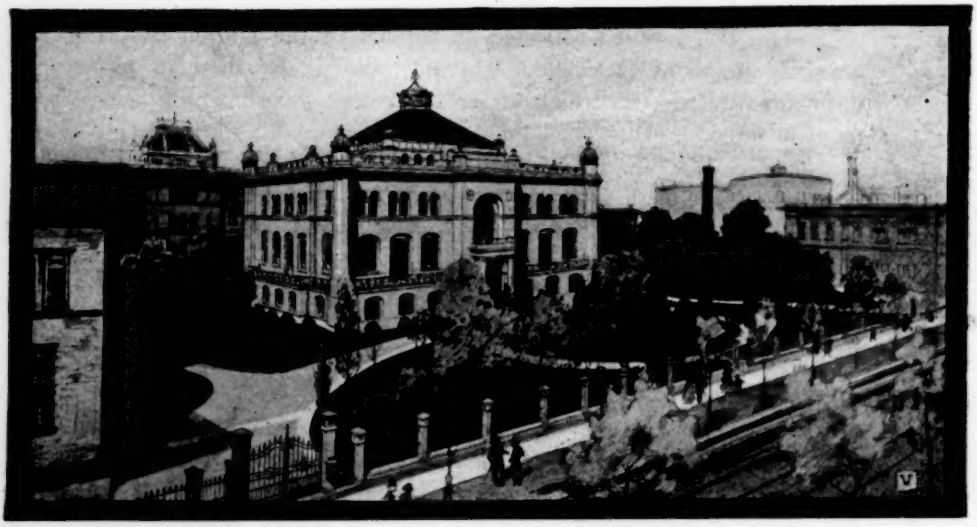
(4) Photometric measurements are also of commercial value. The absence of a standard candle has forced one large electric company to establish a lamp-testing bureau of its own. From every barrel of 200 lamps sent the company ten are taken at random and if any one of these falls below 15 candlepower or is above 17, for a 16 candle, the entire barrel is rejected. But even these standards soon deteriorate and new ones must be obtained from experts. They, like the other standards, come from Germany. A similar test is made of the energy of consumption, five to six million lamps being annually tested by the bureau of this company. The lack of government standards has led to more serious results. The late Professor Rowland testified before the Congressional committee that a certain electrical association voted to call each arc light 2,000 candlepower (if it required 10 amperes of current at a pressure of 45 volts) when in reality it gave only from 400 to 500 candlepower. The consumer thus pays for and supposes he is getting a 2,000 candle light. Even if he knew better there would be no legal redress, for the law fails to define a candlepower as

regards electric lights. Our ideas and laws on this question come from England where many years ago, when gas was introduced in London, Parliament adopted as a standard candle one of definite composition which would burn 120 grains an hour with a government wick. The *incandescent* light companies in this country attempted to employ that standard, which is the legal one, as applied to gas.

(5) The revenue collected on liquors in the United States amounts to about $110,000,000 yearly and is based upon hydrometer readings, for which we have as yet no government instrument to refer to. Oils, acids and other liquids are similarly tested.

Enough has been said to indicate the great need, from a commercial as well as a scientific point, of a national standardizing bureau. Without going much into the history of similar institutions in Europe, let us refer briefly to one. Not to mention one of the earlier receptacles for standards in the British exchequer, nor to dwell on the International Bureau constituted in Paris in 1875—by reason of which France became the leading metrological nation of the world—we come to the more recent and best equipped of all standardizing plants, viz.: that of Germany. The commercial and manufacturing prestige which this latter country has lately developed is thought to be due in no small part to the accuracy and scope of its standardizing equipment. To the Reichsanstalt people have gone for instruments of precision, and German manufacturers have taken advantage of the accuracy of these to sell their wares to countries less favored. The Reichsanstalt is situated at Charlottenburg, a suburb of Berlin, and is the gift of Dr. Werner Siemens. Its general plan was outlined in 1887. It has two objects—research in pure science and the cultivation of precision in the technical application of science. The most distinguished physicist of the realm is sought as official manager. Helmholtz was the first incumbent, and at present Professor Kohlrausch is its head. The Reichanstalt has cost over a million dollars and there are nine buildings. Its annual maintenance costs $75,000 and 95 experts are employed. Papers of research work are published from time to time on various topics—heat, light, electrical work, chemistry and mechanical precision, such,

for example, as the investigation of the hydrogen thermometer, the thermal and electrical conductivity of pure metals from the temperature of liquid air up to 1,000° C. By the thermo-electric couple temperatures have been measured as high as 1,775° C., while with a petroleum-ether thermometer 190° C. below zero is obtained. Here are the most sensitive scales in the world. One



From PEARSON'S MAGAZINE.

THE REICHSANSTALT BUILDINGS AND GROUNDS.

of the two institutions under the control of the Reichanstalt for the calibration of thermometers has tested 350,000 during the last ten years.

England has lately created a bureau of its own on somewhat similar lines to the one in Germany. The bill for our own National Bureau of Standards was drawn up at the suggestion of Pres. Henry S. Pritchett by Dr. S. W. Stratton and others, and was approved March 3, 1901. A building site, consisting of some eight acres, has been selected in the northern suburbs of Washington on an elevation near Rock Creek Park, so situated as to be free from mechanical and electrical disturbances.

The two buildings to be first erected and the fittings are ex-

pected to cost $300,000 and to be ready for occupancy in about a year. Professor Samuel W. Stratton, formerly of The University of Chicago, has been appointed director. It is hoped to make this bureau second to no similar institution in the world. To it states, corporations and individuals may refer questions concerning all sorts of measurements.

Both directly and indirectly this bureau will exert a strong influence for the adoption and use of the metric system. It is probably the greatest step in that direction taken by Congress since 1866. The director and his corps of assistants—specialists of the highest training—will come in touch on the one hand with manufacturers of goods for both domestic and foreign consumption, and the latter means a constant reference to metric weights and measures; on the other hand they will render expert testimony to Congress in general and to the committee on coinage, weights and measures in particular. As scientific experts their influence will always be on the side of metric reform. Dr. Stratton recently said: "There is no doubt in the mind of any thinking person but that a universal system must soon be adopted, and no system offering advantages equal to that of the metric system has yet been devised."

NOTES.

From Melbourne, Australia.—Under date of April 4 there comes the welcome announcement that the Committee of the Federal House of Representatives has recommended the adoption of the decimal coinage system, based on the sovereign. Should this recommendation be adopted, there would be left only two important countries, Great Britain and India, with no semblance of a decimal system of coinage.

For and Against the Metric Bill.—The Metric Bill, referred to in the March number, was, on March 13, ordered favorably reported by the House Committee on Coinage. The hearings participated in by business men and large manufacturers elicited many opinions in favor of the bill and a few opposed to it. The chief objection appears to have come from a committee of the American Society of Mechanical Engineers, whose protest arises from the mistaken idea that the intent is to compel every citizen to use the metric system and to disuse the English. The final

clause of the bill, viz.: that *after January 1, 1907, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States*, is rather ambiguous, and ought to have been eliminated, but the attorney-general of the United States gives as his opinion that there is nothing in the bill which renders this use compulsory for anyone except government employes in government work. The only other objection worth noting was the cost of inaugurating the system in large manufacturing establishments. To quote from an editorial in the New York Tribune: "It is the belief of Director Stratton of the National Bureau of Standards that an erroneous impression prevails in regard to the cost of the change. There are two classes of manufacturers to be considered, he says. One produces wires, tubes, bars and plates, and, on adopting the metric system of measures, must make modifications of the dies and gauges now used. But since it is already customary to do so, to meet special orders, the practice is no novelty and involves no hardship. As for the second class of manufacturers, those who produce machinery, no change whatever will be required in the big and costly features of their plant—lathes, planers and milling machines. The reform will affect only what are known as 'small tools'—dies, taps, reamers and templets. Mr. Stratton is convinced that an exaggerated idea of the expense of this fresh equipment of a machine shop is generally entertained. . . . American manufacturers, who have been backward in this matter, but who cherish hopes of selling their wares abroad, should wake up to the fact that nearly all the foreign countries in which they are likely to find patronage have already adopted the metric system. There are other good reasons for assimilating the standards of this country to those of the world, but trade considerations alone justify the revolution. It is important that the change be voluntary and gradual, not obligatory and abrupt. Within these limitations, though the sooner it comes the better."

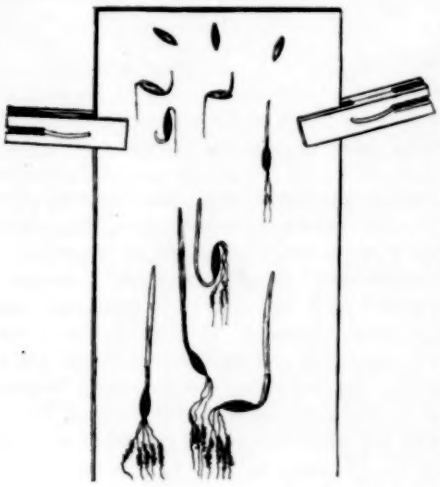
The Coinage Committee has issued an exhaustive Report of 240 pages, consisting of testimony at various hearings, and of letters from manufacturers and business men, which makes a strong document, almost wholly in favor of the bill. Every man who is interested in the metric system should now write to his Congressman and urge him to vote for the measure. The following is an exact copy of the bill:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That on and after the first day of January, nineteen hundred and four, all the departments of the Government of the United States, in the transaction of all business requiring the use of weight and measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system and on and after the first day of January, nineteen hundred and seven, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States."

Notes.

BOTANY.

An Instructive Seed Experiment.—Take two glass plates 5x10 in. and a sheet of heavy felt or carpet paper of the same size. Thoroughly wet the paper, place it on one of the plates and arrange on it a number of oat seeds in such a manner that some may be horizontal and some vertical (both erect and inverted). Place the second glass plate on the seed, after small fragments of the same paper have been inserted to prevent undue pressure. Clamp all together with four spring clothespins and insert one end in water.



This experiment shows many features of seed growth. *Root* and *stem direction*, effect of *varying amounts* of *moisture*, root-hairs (very fine), root-caps, etc. By inverting plate or placing it in a horizontal position other interesting and instructive phenomena may be noted.

Lake View High School, Chicago. H. S. Pepoon.

PHYSICS.

Record of the Disruptive Discharge of a Condenser.—An eight-inch test tube was moderately blackened over a smoky flame to within a short distance of its mouth and then inverted over the rod of a small retort stand. The base of the retort stand was connected with the outside coating of a battery of four Leyden jars. The battery was connected to the poles of a small induction machine, and, when charged as fully as possible, was discharged onto the bottom of the test tube. Ordinarily the spark this battery and machine would furnish, while not at all de-

ficient in quantity, would be only about an inch long. However, under these special conditions, the discharge took place the full length of the test tube with great violence and left the marks of its ramifications strongly outlined on the smoked surface, excepting occasionally when the tube was pierced. The record was then ready for immediate inspection by the class, or, when desired, was preserved by dipping the test tube into a weak alcoholic solution of shellac. Very curious and characteristic forms were thus secured and of a size not obtainable under ordinary conditions with the rather small machine used.

E. C. Woodruff.

PHYSIOLOGY.

Urea and uric-acid.—The idea is prevalent that these excreta are very poisonous, but modern research makes it certain that the toxic effects often ascribed to them are due instead to a group of imperfectly oxidized "alloxuric bases." Under normal conditions these poisonous bases undergo oxidation and form uric-acid, which is inert and harmless. The quantity of these poisonous bases contained in the circulation is regulated largely by the diet. Dr. Sajous, in his Monthly Cyclopædia of Practical Medicine, enumerates the following foods which supply the body with an excess of these excreta: sweetbreads, brains, liver, kidneys, calf's feet, pig's feet, and the meats of *young* animals, such as veal, lamb, spring chicken, squab, etc. It is quite obvious that the effects of the alloxuric poisons can best be avoided by eating the flesh of the adult animals only and by supplying the body liberally with oxygen.

The International Sanitary Congress, which met last February in Havana, passed several resolutions of interest to all hygienists. They declared that the mosquito is the only means, so far demonstrated, of transmitting yellow fever, and recommended measures for exterminating mosquitoes. They advocated the formation of anti-leprosy leagues in every country, and the education of the masses concerning the contagiousness of leprosy and the best means of preventing infection. They also recommended similar leagues against tuberculosis. All countries where malaria exists are asked to make public the recent discoveries concerning the transmission of the disease by the mosquito, and to circulate printed matter on this subject in the public schools and among the people generally, in order that, if possible, the disease may be diminished.

Infection by flies adds one more peril to life. Since the publication by Dr. L. O. Howard, U. S. Entomologist, of his paper on the insects of human excrement, the dangers attending the visits of flies to houses and military camps, etc., are appreciated more than ever. There is no doubt that flies have conveyed typhoid fever to healthy persons, and how much more harm they may do by conveying contagion we can only imagine. The awakening of the public on this question ought to result in a more careful and scientific manner of storing, collecting and destroying garbage, especially horse manure, which is the favorite breeding-ground for the common house-fly as well as other species.

Injurious athletics. Dr. Watson L. Savage, writing in the AMERICAN PHYSICAL EDUCATION REVIEW, recommends "that all games requiring a "continuous severe strain upon the heart of more than thirty seconds, "such as running, swimming, rowing, skating, cycling, tug-of-war, be "eliminated from the sports in our secondary schools, because: (1) They "are entirely unnecessary to the school. (2) They have little or no "educational value to the student. (3) They may abort the future capa-"bilities of the lad in athletics. (4) They endanger the health and future "life of the boy." Most of the other forms of school athletics are recommended.

FRANKLIN W. BARROWS.

Book Reviews.

Laboratory Exercises in Elementary Physics. By FRANKLIN H. AYRES. 14x19 cm., 193 pages. D. Appleton & Co., New York, 1901. 60 cents.

In the introductory pages, Mr. Ayres makes valuable and timely suggestions to the student as to the nature of his work, the importance of good records and the manner of making them. The pupil's attention is also called to the use made of variation and proportion in physical investigations and the principles of these subjects in which a majority of students exhibit a weakness are briefly discussed.

Then follow thirteen exercises in the use of instruments of measure, fifteen on the Mechanics of Solids, ten on the Mechanics of Fluids, ten

on Heat, twenty on Magnetism and Electricity, five on Sound, and eleven on Light—eighty-four in all.

This is a fairly equitable allotment of time to the different subjects, and as more experiments are given than the average class will be able to perform, there is afforded an opportunity for selection. The book closes with a set of twenty-four tables, giving all the data needed for reference and comparison.

The general plan of each exercise is to begin with an enumeration of the essential parts of the apparatus used; then follows a "Preliminary Discussion," stating the principles involved or giving a working definition or formula for the particular thing sought.

Next come very brief but explicit directions to the student as to what he should do and the order of doing.

Stress is laid on the importance of attending strictly to obtaining the experimental data, within the allotted time, while the apparatus is set up, avoiding all computations as far as possible, the latter constituting the next step in the work. Numerous queries are made to guide the student in making the proper deductions, inferences, etc. A logical sequence of operations is insisted upon, and the pupil is not perplexed by elaborate blank tabulations for data and results, but merely instructed to put his work in concise form.

The pupil is frequently cautioned to avoid certain general propensities that the experience of the author has shown obtain in certain connections.

Some teachers may object that Mr. Ayres tells the student too much in the way of definition and formulæ, preferring to hold the student responsible for these from the lecture room discussion of the subject, and to use the laboratory experiment as a test of the pupil's apprehension of the subject.

The work of the publisher is well done, the book being attractive in appearance, strongly bound, the type large and clear, and the illustrations of apparatus excellent. Altogether the book is a credit to its author, and, we trust, will meet a cordial reception at the hands of fellow teachers.

Instructor in Physics, City Schools, St. Joseph, Mo. J. S. Stokes.

Elementary Plant Physiology. By D. T. MacDougal, Ph. D. xii and 138 pages; 108 illustrations. Longmans, Green & Co., New York, 1902. $1.20.

The present volume is intended to take the place of an earlier work by the same author, of the same scope, and, though in a sense a second

edition of the "Experimental Plant Physiology," it is, nevertheless, an entirely new book, thoroughly up to date.

The increasing importance of work in plant physiology in elementary courses in botany both in school and college is, we think, a sign that it is becoming more and more a live subject. Teachers are coming to the opinion that a dynamic viewpoint in botany is the only one that can claim permanent recognition when dealing with their students. The plant as a thing of growth, action and change, is the central thought of a good course in elementary botany, whatever be the materials and methods chosen.

It is well, therefore, that both teacher and student be stimulated by a book, written by an acknowledged authority, which, though simple, is virile and pregnant with suggestion. And the book before us is such an one.

The first chapter deals with growth, a good starting point, since it emphasizes at once that we are dealing with change. We notice that the student's attention is directed to the observation of growth in all kinds of organs, rather than, as has heretofore most generally been done in elementary courses, to one organ, the root, or at best to root and stem. Reproduction and germination (of spores and seeds), the exchange and movements of gases and liquids are then taken up. Under the head of nutrition, the interesting and, economically considered, exceedingly important subject of symbiosis is briefly, though well treated.

The most important contribution to the literature of elementary teaching is the chapter which follows, treating of respiration, digestion and fermentation, and though brief, is very valuable. The reviewer has constantly used this phase of work in his classes and always with the most valuable results.* The closing chapter, on Stimulation and Correlation, turns the attention to the general facts of irritability, a subject of more obvious ecological import.

The general features of the book which appear to be especially worthy of note are the following:

Though primarily a treatment of physiology experimentally conducted, there is a constant and successful endeavor to give the work an ecological turn, so that the teacher will find it useful in conducting a course largely of ecology, if such happens to be the case.

The illustrations are, as they should be in every new text book, for the greater part new, or taken from recent foreign text books or from more recent monographs. This is one of the ways that your busy everyday teacher, cut off from large libraries, may be kept in partial touch with the recent work of botanists and catch some of the modern spirit. The cuts are clean, and the make-up of the whole good.

*"Botany in the Horace Mann School," *Teachers' College Record*, Vol. II, No. 1, pp. 41-45. January, 1901.

The author has a tendency to make use of quantitative experiments. This is definitely good, and it is a good pedagogical practice for teachers to follow this lead whenever possible. The experiments are nearly all simple, and require but inexpensive and readily obtained apparatus, though a very few are, perhaps, too difficult for the high school.

The introductory chapter contains suggestions and information as to material and apparatus, tables of weights and measures, and three "selected courses," which will undoubtedly be useful, in helping teachers whose experience may not be very great, in outlining courses of greater or less length.

F. E. LLOYD.

Reports of Meetings.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The fourteenth meeting of the Association was held on Saturday, April 5, 1902. In the morning, groups of the members visited the Union Glass Works, the Middlesex Bleach, Print and Dye Works, and the Chase Distillery—all located in Somerville, Mass. At noon the members were entertained by the President, Mr. R. P. Williams, at his home in North Cambridge. Luncheon was served and other courtesies rendered. An enjoyable feature of the President's hospitality was an opportunity to examine his collection of old chemistries and alchemies, several of them belonging to the sixteenth century. The afternoon session was held at Boylston Hall, the chemical laboratory of Harvard University. After the transaction of a few items of business, the Association was addressed by Professor Theodore W. Richards, of Harvard University, on "Theory and Practice of Determining Atomic Weights." The address, coming from one who has an international reputation in this field, was intensely interesting. A discussion followed, which was devoted largely to the interpretation of the Harvard entrance requirements in chemistry, stress being laid by Professor Richards on the point that Harvard expects a *good preparation*, but does not restrict the methods used to secure it.

Reported by LYMAN C. NEWELL.

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

A meeting was held on April 4, 1902, in the Board of Education Building, Manhattan, President H. R. Linville in the chair. Miss Kate Burnett Hixon presented a paper, an abstract of which is as follows:

The Peter Cooper High School offers unusual facilities for field work on account of its situation. The last two periods of each school day are made use of at certain times for excursions to the nearby parks, the Aquarium, the Zoölogical Park or some of the vacant lots of the neighborhood. At least once a year the students are taken to the Botanical Gardens to study ecology, stems and their development, movements of leaves, etc. In zoölogical work certain known animals are studied with a view to finding out something first-hand of their life-habits and environment. The study of comparative anatomy and osteology is undertaken at the Museum of Natural History by means of printed questions.

Classes should always be directed by teachers in person. Definite questions given in the field should be followed by class discussions. Single class periods can be spent out of doors, if the material to be studied is near at hand. All trips should be obligatory. Best results are seen in the arousing of the powers of observation, creating a love for nature, and developing a feeling of *cameradie* between teacher and pupil.

Miss Mary D. Womack then read a paper, which is abstracted as follows:

The Grand Street Annex of the Wadleigh High School is situated in the most congested part of the city. Many of the girls have never been even to Central Park, and their ignorance of plant life is correspondingly great. To direct the pupils in field work, typewritten directions for the taking of interesting botanical and zoölogical trips are posted about the school building, giving the points of interest and cost of the trip. These directions are often illustrated. The expenses of the trip are defrayed by the pupils, one of their number acting as treasurer. The trips are obligatory. The students are required to make notes in the field, in studying plant societies, physiographic conditions, animals, birds, etc. Lantern lectures are given at the school in connection with the trips. Pupils are urged to work in the parks alone, and good results are obtained in this way as well as from trips in vacation. Preparatory to these trips, they are given general instructions as to what to notice and to write up in their note books. Field work is not only of importance in instruction to these girls, but also to their health.

In the informal discussion which ensued after the reading of these papers many good ideas were brought out. It was the general con-

sensus of opinion that field work is a valued adjunct of class work, and that at least one excursion should be made each term.

Reported by G. W. HUNTER JR., Secretary.

NATURAL SCIENCE ASSOCIATION OF ONTARIO.

The association met in annual convention at Toronto on April 1 and 2, 1902. The attendance was somewhat smaller than last year, but the interest was well sustained.

The President, Mr. G. A. Smith, of Parkdale Collegiate Institute, chose as the subject of his presidential address, "Some Palæontological Results." He outlined the history of palæontology in an attractive way and aroused much interest. A unanimous request was made for the publication in full of the paper in the Proceedings.

Prof. M. W. Doherty, of the Department of Entomology in the Ontario Agricultural College, Guelph, gave an account of the formation and work of the "Wellington Field Naturalists' Club." The club was organized to encourage the study of nature and to direct the efforts of those engaged in the study of natural history so as to secure the best results, and to record the results obtained. It is the intention of the club to hold an exhibition in the autumn, offering prizes for the best collections of insects, weeds, weed seeds, nature photographs, etc.

The secretary, Mr. E. L. Hill, Guelph, brought before the association the claims of SCHOOL SCIENCE. He pointed out that every number of this excellent periodical had contained articles of exceptional merit and of the greatest usefulness to science teachers who desired to keep abreast of the times. He also gave a brief review of some recent scientific books, strongly recommending Appleton's Twentieth Century series for school use, and Coulter & Chamberlain's "Seed Plants" for advanced work.

The Honorary President, W. Lash Miller, Ph. D., F. R. S. C., gave an admirable lecture in the Chemical Department of the University of Toronto, on "Chemical and Physical Change." This was illustrated by experiments illustrative of the reversing of chemical reaction by change of pressure, etc. Berthelot's Law of maximum work was shown to have been accepted in some cases because of the political power of its author, who had in his hands the appointing of chemists to many of the best positions in France. Dr. Miller created some amusement in offering an apology to the members of the Department of Physics (who were the guests of the Science Association), because a small quantity of hydric sulphide had escaped during an experiment. He stated that he understood that physics teachers were especially sensitive to that gas, carrying their dislike so far as to refrain from eating eggs lest their breath should tarnish the brass of the physical apparatus.

Mr. J. S. Plaskett, electrical expert of the University of Toronto,

gave an illustrated lecture on "Translation of Color into Monochrome by Photography." Mr. Plaskett showed the defects of ordinary plates, and the advantages secured by the use of isochromatic. He also exhibited some admirable examples of color-photography of his own production.

Mr. Carl Lehmann, of the Jarvis St. Collegiate Institute, Toronto, gave a description of the various methods employed in color-photography, and showed that it was possible by simple apparatus, to produce tolerably good color photographs.

Reported by E. L. Hill.

MICHIGAN SCHOOLMASTERS' CLUB—PHYSICS CONFERENCE.

The Conference met in the Lecture Room of the Physical Laboratory of the University of Michigan on the afternoons of March 28 and 29. The program as carried out was as follows:

1. The Laboratory Note Book: What? How? When? Discussed by Messrs. Bemis, Minchin, Morse, Randall, Ross and Slater.
2. The Concentration Cell. Prof. H. S. Carhart, Ann Arbor.
3. The Singing and the Speaking Arc. Prof. Karl E. Guthe, Ann Arbor.
4. The Physical Laboratory of the Joliet Township High School. Mr. Walter J. Risley, Joliet, Ill.
5. Purification of Mercury. Mr. W. H. Hawkes, Ann Arbor.
6. Pupin's Invention. Prof. G. W. Patterson, Ann Arbor.
7. The Nernst Lamp. Mr. C. W. Carman, Chicago.
8. Index of Refraction of Liquids. Mr. C. H. Slater, Pontiac.
9. An Optical Device for Compounding Simple Harmonic Motion. Mr. H. D. Minchin, Detroit.
10. Opaque Projection. Mr. C. W. Carman, Chicago.

The program proved to be one of unusual interest as shown by the large attendance during both sessions of the Conference. The discussion of the note-book question showed great divergence of opinion among teachers in the manner of its preparation. This difference of views was made still more apparent on comparing the sample note books of pupils' work that were exhibited. Prof. Carhart's talk on the Concentration Cell was an introduction to an investigation in which he is engaged that bids fair to overturn some of the modern theories regarding such cells. Dr. Guthe accompanied his paper by many surprising and interesting experiments with singing and speaking arcs. Prof. Patterson essayed a difficult task—to explain an intensely mathematical subject—to a non-mathematical audience. To say that he succeeded admirably is to state the facts very mildly.

At the business meeting the following officers were elected for the next conference: Chairman, Mr. C. F. Adams, Detroit; secretary, Mr.

F. R. Gorton, Ypsilanti; treasurer, Mr. C. H. Slater, Pontiac. A proposition to abandon the Physics Conference as an adjunct of the Michigan Schoolmasters' Club and to organize in its stead a Physics Section of the Michigan Academy of Science provoked a spirited discussion and revealed the fact that the great body of the members of the Conference was opposed to the measure.

Reported by H. N. CHUTE.

MICHIGAN SCHOOL MASTERS' CLUB.

CONFERENCE OF THE BIOLOGICAL SECTION.

(Continued from page 127.)

Joint Session with the Michigan Academy of Sciences.

In a paper on "Original Work for the High-School Teacher," Mr. E. L. Mosley, who has done so much for science in the Sandusky (O.) High School, gave a most striking illustration, a concrete example, of a piece of original work he had done in locating buried valleys of streams into Sandusky Bay. His boys accompanied him at one time or another, and one of them helped in the discovery of an old creek bottom that explained one of the problems that was at the time puzzling them. It was shown that such work may furnish a valuable basis for futur- engineering operations,....The conclusion reached was that the valleys now filled with mud and covered with water must have existed before the waters of Lake Erie had been raised so far westward, and that if this rise continued, ultimately Sandusky, Toledo, and then Chicago would be submerged.

Questions that might occur to a teacher wishing to take up original work were then discussed. To get a subject, a teacher may become a member of the local academy of sciences or attend the meeting of other scientific bodies. Local problems could be suggested by visiting scientists. "A desire to know is the best stimulus to investigation." Time for original work may be made by giving up other things...Both the desire to make money and the indisposition to spending it for scientific purposes must be curbed. Most of all is the preservation of health of the teacher; observation trips and the work of collecting for the classes will give the necessary exercise. Frequent change of position is detrimental, both to the interests of the school and most original work that the teacher might undertake. "The teacher of natural science who would imbue his pupils with the spirit of investigation should not be content to invoke their assistance in prosecuting his own researches. He should inspire them with a love of nature. To do this, he must take them into the country"....to see the things that cannot be brought to the school room.

In the discussion following, two of the University men held that it was difficult to find problems on which high-school teachers could work and that they did not usually have the time, though it was held that some sort of original work was almost essential for the best kind of teaching. Yet the principal speaker on this topic, a high-school teacher, had done very creditable science work, presenting at the opening of his paper an unfinished piece of work, which was original, to say the least.

Another member, however, presented a more encouraging view of this unpromising situation. He said the idea which holds teachers back from attempting original work is that they must do something great or nothing at all; but little things add to science. There are scientists in the state who wish to enlist teachers in small problems of distribution. Very simple things can be done along this line, which, in their broader meaning, may be very complex. The mere collection of material, when the locality is known, is of importance.

The description of "A New Biological Laboratory," by Professor S. O. Mast, of Hope College, was interesting, and as there are always some readers who may be prospective builders, a short account, with plans, is given on another page of this issue.

In discussing this paper, Miss Edith Pettee, of the Eastern High School, Detroit, gave a description of their new biological laboratory, and some of the principal features are here given, as it presents the high-school side of the same question. The laboratory is a large room, with three double windows on the north side. Before each of these is a large flat-iron-shaped table, seating eight pupils. A plate glass partition, nearly as large as the east end of the laboratory, separates the latter from the conservatory. This is of glass sides and top, with cement floor. An aquarium table stands in the center. The plant benches are around the sides, covered with metal and lined with asbestos. The steam pipes are under these—not a satisfactory way. At the opposite end of the laboratory is a recitation room. At the side of the laboratory is a small store room, which also contains a small hot water heater, to supply hot water faucets in the laboratory sink. There are cases for books and apparatus in the laboratory room.

In a short talk on "Methods by which new Varieties of Cultivated Plants are Originated," Professor C. F. Wheeler, of the Michigan Agricultural College, gave many ways in which the horticulturist produces such interesting results. Some new products were mentioned—a daisy, four inches across, will soon be common property. In illustration of the ability of plants to vary with their surroundings, it was said that the "dented corn" of the South may be changed to the "flint corn" of the North after three years' planting in the latter latitude. In the discussion that followed, Professor Davis called attention to the fact that the garden radish, the cabbage and the cauliflower were the result of

selection acting on the plants of the mustard family that had, respectively, somewhat thickened roots, or leaves, or flower-stalks.

Mr. J. W. Matthews, of the Western High School, Detroit, then spoke on "The Kind of Zoölogy for High-School Work," saying in substance: The discussion of the subject of zoölogy in the high school should answer three questions: Why study zoölogy in the high school? When shall it come in the course of study? What shall be the branch of zoölogy presented.

There is no study in the curriculum that can produce better development of the powers of observation, comparison, and classification. No other subject gives such natural material for the development of observation, which is the first step in all study; and comparison, which establishes the facts thus gained; and classification, the logical conclusion. Pupils readily feel at this age the philosophy of the general laws of life, and need the breadth given to thought by considering human life in connection with animal life.

The best time for zoölogy is the second year of the high-school course; following a year of botany, which shall have consisted of the study of plants as a whole, their habitats, when they flower, their method of flowering, their uses, etc. In fact, much work in "God's laboratory" rather than confinement within the walls of a building with expensive apparatus and a few plants. A high school following such a plan for five years sent out six students who specialized in biology and were chosen assistants in the University of Michigan; four others, who went from college to teach biology in the public schools, or to follow lines of nature work; thus making ten pupils in that period of time inspired to choose life work in biology.

The conference closed with a lecture on "The Germicidal Action of Metals and Sunlight," by Dr. F. G. Novy, of the University of Michigan. On account of his researches along this line, much interest was taken in what was said, an abstract of which is here presented:—

The surface or contact action of metals has been studied by chemists for many years. It is well known that certain metals, as platinum, and especially palladium, absorb relatively enormous volumes of hydrogen. The gas is held in combination with the metal and is easily given off in a dissociated or active condition. As a result, palladium-hydrogen is capable of exerting a marked oxidizing action. It may convert, as Hoppe-Seyler pointed out, benzol into phenol, aldehydes into acids, liberate iodine from potassium iodide, etc. Moreover, hydrogen peroxide is formed when it is brought into contact with water.

The contact action of platinum is especially seen in the manufacture of fuming sulphuric acid by the new method. When platinized asbestos at a high temperature is brought into contact with oxygen and sulphur dioxide, the metal acts as an oxygen carrier and the result is the formation

of sulphur trioxide or sulphuric acid. By this procedure it is possible to prepare pure fuming sulphuric acid, and it is more than likely that the "lead chamber" method of manufacture will be entirely done away with.

In 1889, Dr. Miller, the well known American dentist of Berlin, showed that certain metals, such as gold and copper, exerted a marked germicidal action when brought into contact with bacteria. He explained this action as probably due to oxygen condensation on the surface of the metal. Behring, the discoverer of diphtheria antitoxine, repeated and confirmed Miller's experiments, but the explanation which he offered was very different. He held that the bacteria, by means of their soluble chemical products, dissolved traces of the metals and that thus the germicidal action was brought about. In their studies upon the formation of organic peroxides, Drs. Freer and Novy showed that these substances are readily formed when some metal or even fabric was introduced into the mixture of the ingredients. In other words, the surface or contact action of metals was manifested in much the same way as in the manufacture of sulphuric acid by means of contact with platinum. The view was expressed that probably the germicidal action of metals was due, not so much to the solution of the metal employed, as to the formation of peroxides by surface action.

It is well known that sunlight is destructive to bacteria, and the only explanation from a chemical standpoint which has been heretofore brought forward is that hydrogen peroxide is formed under the influence of the sun's rays. There can be very little doubt about the formation of this substance under those conditions, but the amount that is present is hardly sufficient to account for the rapid and intense germicidal action observed. The ultra violet rays are especially active in this regard. The explanation of the action of the sun's rays must be due either to the formation of powerful organic peroxides, such as those described by Drs. Freer and Novy, or to ionization. Investigations along these lines are now being carried on in the Hygienic Laboratory of the University.

Reported by L. MUBBACH.

DISCUSSION OF QUESTIONS.

37. What cases of chemical arithmetic should a senior class in high school be required to master?

The solution of problems in chemical arithmetic demands three things of students: (1) A knowledge of numbers. (2) Familiarity with arithmetical and simple algebraical operations, and (3) Ability to perceive relations. The first requisite may safely be assumed, but the second, elementary as it is, can by no means be taken for granted. Every year a portion of my class is utterly unable to solve simple examples

in percentage and in proportion, to say nothing of being slow, careless and inaccurate in employing the four fundamental operations. The third requisite is never acquired by some, is seldom possessed by many at the beginning, and seems to be desired by few. I hope all teachers are not confronted by similar conditions, though some have expressed their convictions in about this way. But the situation is not hopeless, because we know the defects. Those students who are strangers to the simple operations are turned over to the teacher of mathematics for definite instruction in those processes demanded in the solution of chemical problems. They may have never learned percentage and proportion in the grammar school. As a rule, teachers of mathematics are willing to assist students with a real difficulty. It is the "eternally stupid" ones who see nothing at all in mathematics whom he does not wish to take his time. The third requisite—ability to perceive relations—may be acquired by students by a judicious performance of these rules: (1) *Practice reading problems.* Select the thoughts from the statement. Often relations are not perceived because the language is not comprehended. Get the kernel from the shell. See mentally what the problem means before giving a single thought to its solution. This is especially desirable with problems involving equations, particularly when both weight and volume are to be considered. (2) *Indicate the solution without performing the work.* This plan fixes the attention on one thing, viz.; the relation of parts. The mind is not bothered with numbers, and can therefore concentrate on the part to which thought must really be given. (3) *Forecast the answer and, if possible, its approximate value.* This operation is not difficult. It often reveals relations very quickly. It is eminently practical, and is employed in many industries. It likewise trains one to be a quick worker. Such a plan is applicable to problems involving metric transformations, corrections for pressure and temperature applied to gas volumes and density.

Teachers who assist students along the lines suggested will find their labors lighter as the subject advances. Problems will not be so distasteful, nor will students regard them as extra burdens. It is advisable also to connect the problems with the laboratory work. Let them arise naturally from experiments. This plan may be followed in many cases. A class instructed from this standpoint should be able to perform in their fourth year of general high-school work problems involving (*a*) the metric transformations, (*b*) Boyle's Law, (*c*) Charles' Law, (*d*) correction of gas volumes for pressure, temperature, and water vapor, (*e*) percentage composition, (*f*) deduction of simplest formula from percentage composition, (*g*) all questions arising from *known* equations, (*h*) density and molecular weight, (*i*) simple atomic weight determinations, (*j*) combination of gases by volume.

LYMAN C. NEWELL.